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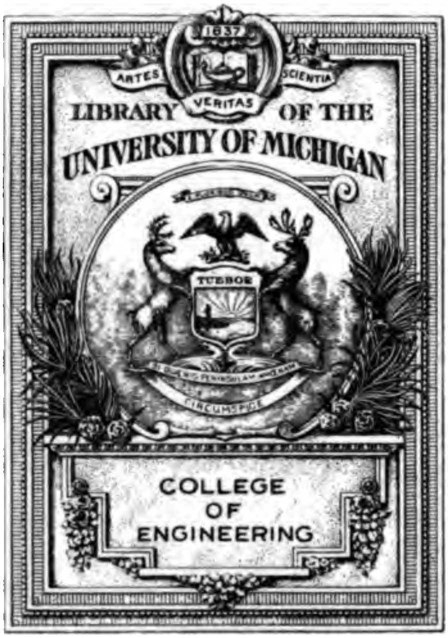

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DEVELOPMENT OF A PHOTO-VELOCIMETER FOR MEASURING SIMULTANEOUSLY THE MAXIMUM VELOCITIES OF RECOIL AND OF PROJECTILE, AND ITS APPLICATION TO THE FREE RECOIL OF SMALL ARM RIFLES WITH CHARGES OF BLACK AND SMOKELESS POWDERS.*

BY FIRST LIEUTENANT B. W. DUNN, ORDNANCE DEPARTMENT.

INTRODUCTION.

Our knowledge of the effects of powder pressure in modern ordnance will advance directly with the accuracy of our simultaneous measurements of small intervals of time and space. When we can trace accurately the change in velocity of a known mass, we can state the law of development of the resultant force acting on it. To the French is due the credit of attacking, from the standpoint of dynamic rather than static measurement, the more difficult problems that confront the Ordnance Engineer. The free recoil carriage of Colonel Sebert and the work done with it by Colonel Sebert and Captain Hugoniot suggested the best method for investigating problems in interior ballistics. The published records of experiments made with this carriage, however, justify doubt as to the reliability of data obtained from it. That different investigators should obtain different results is readily understood when practical details are examined. In the case of the 10 centimeter cannon, the total recoil during development of maximum powder pressure is about 0.02-inch and the total time about 0.001 second. It is simply impossible to obtain, with this instrument, a satisfactory time space record for these limits.

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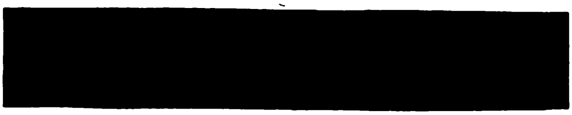
* Printed by authority of the Chief of Ordnance, U. S. Army.

It will not suffice to use a high power microscope to translate an infinitesimal record. As in photography, the details in the original cannot be improved upon in the enlarged reproduction. The original record must be produced on a *magnified scale;* the pen must move more rapidly than the hand and yet in complete unison with it. Perfect conditions require a massless pen and American ingenuity has found this in a ray of light. In photography the experimenter has a new tool for his set and he can now form many new combinations which secure for him increased accuracy in all measurements and enable him to accomplish, in some cases, the previously unattainable.

This new application of an old tool was introduced in 1891 by the Ordnance Department of the Army, when the Photo-Retardograph was constructed.* During the same year the Ordnance Department constructed a photo-chronograph, whose accuracy may be judged by the fact that it was used, with target intervals of only two feet, to obtain five consecutive velocities of a projectile moving 1345 feet per second, and the extreme variation was only two feet per second. Figure 1 shows a reproduction of one of the records from this chronograph.

Fig. 1.



The next step was the introduction, some years later, of the beautiful Polarizing Photo-Chronograph of the Artillery School, an instrument which, from the wide publication of its merits, has obtained a well-deserved international reputation. In theory, at least, this instrument improved upon its predecessor, the ordnance photo-chronograph, by supplying a massles shutter to take the place of the induction coil whose secondary sparks had been photographed to show how much of the photographic time scale corresponded to the required time interval.

The following paper contains some useful data, but its principal value is to be found in its illustration of the fact that, with photography added to the tools available, a simple and a cheap combination can be made for the investigation of any special problem in view—a combination which will give the investigator a sensitive, accurate and valuable instrument.

When smokeless powders were introduced for small arms, exaggerated claims were made for their non-recoil properties. The spring dynamometer, whose measurements are given in foot pounds, was the only instrument available at Frankford Arsenal for measuring recoil. The capacity of this instrument was exhausted without throwing much light on the subject, and a very interesting report by Colonel Farley was published in report of Chief of Ordnance, U. S. Army, 1893.

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* See *Artillery Journal* Nos. 1 and 2, vol. VII.

The suggestion of the writer, that by using photography, in connection with other appliances on hand, a reliable free-recoil carriage could be improvised, was readily approved by Colonel Farley, and the experiments were made during the winter of 1895-96.

GENERAL DESIGN OF APPARATUS.

The special problem to be investigated was:

A small arm rifle of known mass is mounted on rollers, and, excepting a small frictional resistance to be determined, recoils freely. It is desired to know the velocity of recoil as a function of recoil, the velocity of projectile as a function of the range and the relative positions of piece and projectile at any instant. The idea in assembled apparatus was to fasten a photographic plate to the recoiling piece, to record thereon a time scale and to use this time scale as a chronograph for tracing the successive velocities of projectile by photographing on the same plate the secondary sparks from an induction coil, produced as the projectile passed through successive screens placed at ten feet intervals. If only the motion of gun had been desired the photographic time scale would have sufficed.

This simple method of attaching a plate to a body to be moved and recording thereon a photographic time scale will give, in the majority of cases, the data required to measure the resultant of moving forces.

The exact influence of any recoil check, the amount of energy accumulated in gun and carriage at any instant, the rate at which this energy is being absorbed at any point in path of recoil, etc., are illustrations of cases to which the method is directly applicable.

The details of apparatus for securing the time scale should depend upon the accuracy desired. In this case the most convenient one was selected. A slow fork giving about 250 breaks per second was used as a "contact breaker" for a Ruhmkorf induction coil, the secondary spark being photographed to form the main divisions of time scale. For greater accuracy, a high fork and sunlight or electric light should be used to record a continuous sinusoid similar to that given by the photo-retardograph.

The rifle, with surplus stock and magazine removed to offset, approximately, the extra weight of mountings and to prevent center of gravity being too far removed from axis of bore, is mounted to roll freely on a metal track in a dark box (Figs. 1 and 7).

A sensitive plate, 10 inches long and about 1½ inches wide, is securely attached to stock of rifle so that the plate can have no motion other than that of the rifle (Figs. 4 and 7).

An attachment to the right prong (Fig. 2) of tuning fork permits its use as a "contact breaker" for the Ruhmkorf induction coil No. 1, Fig. 1.

The spring, s, Fig. 2, and the screw, a, are in the electric circuit passing through magnets which sustain vibration of fork; the spring, s^1, and adjusting screw a^1 are in the primary circuit of coil No. 1. The simplest arrangement would seem to be to put the coil in the circuit through fork magnets but this did not prove satisfactory. The breaking of contact between s and a does not occur at a definite point and with the extreme certainty and regularity required.

With the fork at rest, the spring, s^1, and screw a, are adjusted to a delicate contact.

This insures that when the fork is vibrating and the right prong is moving inward, the screw, a^2, will strike the light watch spring when the prong has its maximum velocity and thus produce a *quick* and *decided* break in primary circuit. The tone of spring, s^1, when vibrating independently, is made higher than that of the fork so that it will not lose contact with end of screw, a^2, until, on return path of prong, the spring is arrested by again coming into contact with end of screw, a^1, re-establishing the primary current.

This arrangement works with perfect satisfaction. The breaking and making of primary current is accomplished in perfect unison with the vibrations of fork.

The primary current of coil No. 2 flows successively through all the screen targets, Fig. 1. This current is broken when the bullet passes through any screen and by the arrangement shown in Fig. 5 and target No. 4, Fig. 1, the current is re-established through the succeeding screen before the bullet reaches it.

The device for doing this is quite simple and gave perfect satisfaction. As the current enters the target (No. 4, Fig. 1, for

example) the only path available for it is that through the screen —the alternate circuit through lower part of target (Fig. 5) being kept open by the force exerted on small pistons and springs by the tension of wires in screen. As soon as this tension is relieved, by the breaking of one or more of these wires as the bullet passes through, the piston affected moves quickly, under action of compressed spring, across the small space separating it from the insulated metal plate under it. When it reaches this plate the current is re-established through the next target.

By this arrangement, a break of the primary current of coil No. 2 is secured as often as desired and the velocity of bullet can be measured at any number of points in the same trajectory. The electrical resistances of the various circuits are kept as constant as passible. The only one that tends to change is the resistance in primary circuit of coil No. 2, and it will be noticed that the arrangement described throws in the resistance of only one target at a time.

The secondary circuits of both coils, well insulated, are led to the terminals in lens mounting shown in Fig. 4.

A photographic record is secured of each secondary spark produced during recoil over first ten inches. There is practically no limit to the length of record obtainable. Fig. 8 illustrates the record.

The origin sparks are made by breaking each of the primary circuits once, by hand, just before firing the gun.

The tuning fork is then set in motion and, to prevent a great number of time sparks being recorded at the origin of time scale, between the turning on of current through coil No. 1 and the beginning of recoil,—thereby injuring that portion of negative by solarization—a simple shunt for coil No. 1, which is broken by first motion of gun in recoil is used. The advantage of this shunt is questionable. It served its purpose and improved the appearance of negatives; but more extended use of apparatus will probably show that, to secure best results, the time sparks should be turned on before recoil begins. After the stream of sparks is once established a condition very nearly approaching a vacuum exists in the small space (about 0''.03) between terminals. The resistance offered by this space to the first spark should therefore be comparatively large.

The Leyden jars connected with secondary circuits (Fig. 1) are also experimental. Without them, the secondary spark is comparatively dim and of long duration, its photographic record on a plate in motion being a line (see Fig. 1 page 2.) With them, the spark is brilliant and practically instantaneous, its record being about as shown in Fig. 8.

In all photographic records there is a gradual shading effect and the absolute edge of a circle or line of light is more or less ill-defined when viewed through a mircroscope. This causes appreciable errors in measured data.

Fig. 8 shows a fine line or shadow extending through each spark perpendicular to direction of motion. In measuring the distance from one spark to another this shadow is of great assistance, for it is easy to place cross wire of microscope on center of shadow.

Fig. 4 shows method of producing this shadow. A very small wire is stretched perpendicularly, near the secondary terminals and between them and the lens. *The lens is focused on this wire.* When a spark is produced it is used simply as a background of light to permit a sharp shadow picture to be made of this stationary wire. Since the photographic plate is moving rapidly, the light must be instantaneous. If it should last long enough for the plate to move over a distance equal to width of shadow, that part of the sensitive film would be exposed and definition of shadow impaired. With Leyden jars, the duration of light is sufficiently short: without them, the shadow wire is of no value. The jars cause successive discharges, sufficiently separated in time to produce separate photographic records. The number of such discharges corresponding to a single break in primary is sometimes very great. The writer has recorded photographically more than a hundred.

The record of these successive discharges shows very clearly that the rate of production decreases as the potential difference decreases. The fact that each vibration of fork generally produces a number of sparks is not a source of error since the record shows these sparks in groups and it is easy to measure the distances between the *first* sparks in the successive groups. As soon as the current is re-established, these secondary discharges cease. Similar effects are observed when the jars are not used. For a single break in primary, without remaking, the record is a comparatively long line. When the circuit is closed very quickly after the break the light is stopped by the opposite induction and the record becomes a comparatively short line.

There is an appreciable time interval between the break of primary circuit and the rise of potential to the value necessary to produce the secondary spark; and this delay is increased by introduction of Leyden jars. If the delay affects all sparks equally, it is not detrimental to accuracy ; and it should affect them equally, for all practical purposes, since the record is made in a few hundredths of a second, and during this time the primary current constants do not change appreciably. Excepting the tuning fork, which was mounted in another room, the apparatus was assembled in the velocity gallery of the proof house. It is just possible that atmospheric resistances to bullet's motion are appreciably irregular and abnormal when the firing takes place in a closed gallery.

By the general method herein described, recoil data for any gun and for any condition of mounting can be readily obtained. If properly located, the sensitive plate will show very clearly the irregular motions in gun, such as the jump, and will always show the corresponding position of projectile.

USE OF APPARATUS.

As a result of the excellent work accomplished by Messrs. Sébert, Hugoniot, Helie and others, during the last two decades, our knowledge of recoil has been very materially advanced.

Recoil is divided for this discussion into two stages, (1) that which takes place while the projectile is in the bore and (2) that which takes place after base of projectile leaves face of muzzle. The first stage is the most difficult to investigate experimentally. Its great importance is due to its connection with the science of interior ballistics. This report has to do with the second stage only, in the investigation of which the principal object is to obtain reliable data on the *maximum* velocity of free recoil for given conditions of loading. For a satisfactory investigation of the first stage a more refined apparatus than any as yet constructed is thought to be necessary. For a general design of such an apparatus see the article on Photo-Retardograph.

In order to connect maximum velocity of free recoil with maximum velocity of projectile, so that a measure of either will permit accurate calculation of the other, we need to know only, for the conditions of loading, the value of A in the equation

$$W_1 V_1 = wv + A\pi. \qquad (1)$$

W_1 = weight of piece mounted to recoil freely.
w = weight of projectile.
π = weight of powder charge.
V_1 = maximum velocity of free recoil.
v = maximum velocity of projectile (usually taken as muzzle velocity*).

---

* As will appear later in this report, small arm projectiles should be considered as having their maximum velocities at points from 20 to 30 feet in advance of muzzle. It cannot be stated with certainy as yet that their motion is accelerated appreciably after leaving muzzle, but it is safe to say, based on experimental data, that they suffer no retardation over that distance.

The term $A\ \pi$, Eq. (1), expresses the difference in quantities of motion in gun and in projectile at the instant of maximum velocity of free recoil. In practice, this difference is the quantity of motion in powder gases and in the atmosphere set in motion by them; but, for simplicity, the atmosphere is neglected and A is taken to be the mean velocity of powder gases corresponding to V_1. For given conditions of loading, A will be as constant as the action of powder is uniform. The same charge will not always give the same velocity and A will rise or fall with the efficiency of powder.

When the base of projectile leaves the muzzle and the powder gases are free to expand, their unexpended force,—due to their tension at that instant and to subsequent combustion,—operates to increase momentum of gun, powder charge, atmosphere and bullet. The greater this unexpended or reserve force, the greater will be the increase in recoil velocity. The increase in mean velocity of powder charge, however, and therefore, the value of its maximum mean velocity, A, depends not only on the amount of this reserve force, but on the mass on which it operates—the mass of the charge. For instance, when 68 grains of black powder are fired from the .45 caliber Springfield, the quantity of motion in gun increases from about 3.0329, as bullet leaves muzzle, to a maximum of about 3.5379, giving for A the value, 2258; and when 29 grains of Rifleite powder are fired from the same gun, giving nearly the same initial velocity to bullet, the corresponding data ore 2.8335, 3.1589 and 3236. The reserve force of black powder charge is about 1.55 times that of the Rifleite; but the difference in masses of charges causes the maximum mean velocity of the Rifleite to be about 1.43 times that of the black powder charge.

The coefficient, A, decreases rapidly with reduction of powder charge, other things being equal. A reduction from 68 to 58 grains of black powder, in the .45 caliber rifle, reduces it from 2258 to about 1716. Reducing the charge reduces the reserve force of the powder. The tension of the gases as the bullet leaves the muzzle is less and the quantity of powder unburned at that time is less. This coefficient decreases also with increase in length of bore.

Sébert and Hugoniot say "The constancy of the coefficient π in the second member cannot be considered as absolute; it is probable that it will cease when π becomes greater or less than certain limits; besides, the coefficient undoubtedly depends on the nature of the powder; finally, it varies with the weight of

the projectile as well as with the length of the bore. It is a function of these various quantities, a function which is not known, and one whose nature only can be determined, even by the most searching investigation."

It is exceedingly important to know the value of *A* for the different guns and conditions of loading in our service. The only instrument heretofore available for obtaining the necessary data, the Sébert velocimeter, is an expensive apparatus (cost about $5000) and it is subject to serious objections, the two principal ones being (1) that it is necessary to use as a basis of time measurement a tuning fork record made by the stylus method, and (2) that the tuning fork must be placed in close proximity to the gun where it is subject to all the disturbing influences due to shock of discharge.

Some of the advantages claimed for the instrument now presented are:

1. A photographic record of tuning fork vibrations. For discussion of advantages of this over stylus method, see "Development of Photo-Retardograph, etc."
2. Our ability to place the fork at any distance from the gun, thus relieving it from the disturbing influences of shock of discharge.
3. The same negative is made to give data for calculating successive velocities of bullet as well as successive velocities of free recoil.
4. Simplicity and cheapness of apparatus. The apparatus herein described was assembled at a nominal cost and the results given by it are, on the whole, very satisfactory.
5. Permanency of records for filing and future reference.
6. The instrument does not require for its operation either sunlight or an arc light.

The use of sunlight would complicate the apparatus and make its operation dependent upon the weather; while the cost of plant for arc light would be many times greater than cost of entire apparatus. The use of arc light would also interfere with portability of instrument which is one of its chief advantages.

7. The length of time scale which corresponds to the required time interval is accurately defined by shadow lines in the photograph. These shadow lines are of great practical advantage. They eliminate the probable errors in measured data due to the difficulty in determining accurately the beginning and the end of light signals.

MEASURED DATA FROM THIS EXPERIMENT.

Referring to Fig. 8, Plate 1, time sparks, it will be seen that all we know concerning the interval between origin spark and the first time spark recorded is that its time value is less than the duration of one vibration of fork. To obtain, approximately, the time from origin to first spark recorded, recourse was had to data given in Tables II and IV of Colonel Farley's report. From velocities of bullet at different points in bore, the times occupied by it in passing over the successive sections of bore were calculated and by summation the following values for total times of passage through bore were obtained:

Caliber. inch.	Powder.	Bullet.	Time of passage through bore. Seconds.
.45	Black—68 grains	500 grains	0.002518
.30	Smokeless—30 grains.	220 grains	0.001642

The distance, X_1, traversed by gun during this time was obtained from the formula

$$W_1 X_1 = \left(w + \frac{\pi}{2}\right) x,$$

x being the distance from base of bullet to face of muzzle.

In this way, the time scale from experimental data was connected with the origin of recoil. In obtaining time scale, it is very advantageous to have the "make" as well as the "break" sparks recorded; for, two sets of simultaneous values of time and distance are thus obtained. As a general thing, the "make" sparks were not recorded. With more refined appliances, storage batteries and current measuring instruments, not available at Frankford Arsenal, this "make" spark could always be obtained.

In the following tables are given the data obtained under five sets of conditions. For each set of conditions the data of a single observation are presented. The table of condensed data is based upon the mean results from a number of observations made under the same conditions.

The measured data obtained from a negative consist of the successive distances from origin of recoil to time sparks and the corresponding distances to bullet sparks. The interval between any two consecutive time sparks gives the distance passed over by piece during the time of one vibration of fork, or, as stated in tables, the velocity of recoil (inches) per vibration of fork. The interval between any two bullet sparks, divided by mean velocity of recoil for that interval, gives the time occupied by bullet in passing over the interval between the two targets corresponding to the bullet sparks considered. From this time, and the known interval between targets, the mean velocity of bullet for the interval is obtained. The distance of middle point of target interval from muzzle wire is given under the heading—Range.

It is readily seen that any error in values of time and distance, used to obtain velocity of bullet in feet per second, is largely multiplied. So long as the velocity of recoil is changing rapidly and un-uniformly, the time value of interval between bullet sparks is relatively inaccurate. Before velocity of recoil reaches a maximum and becomes sensibly constant, the bullet is from 20 to 30 feet from the muzzle and all bullet velocities for ranges less than 20 feet are, therefore, less reliable than those given for ranges greater than 20 feet.

To afford a check, the mean velocity of bullet for the extreme range, 90.9 feet, was simultaneously measured with the Boulengé chronograph, and the results are given in foot notes to tables.

BLACK POWDER.—0.45 CALIBER.

Data From a Single Observation.—Table I.

The measured recoil data from this negative appear in columns 2, 3 and 14 of Table I.

The approximate velocities of recoil, given by first differences of data in columns 2 and 3, appear in columns 4 and 5. The approximate velocities, columns 4 and 5, are adjusted by taking successive means, thereby obtaining the values in columns 8 and 9. For determination of true velocity curve, as a function of recoil, reliance is placed upon the mean curve, No. 1, Plate II, obtained by graphical construction in the following manner. From maximum velocity to end of recoil recorded it is assumed that retardation is constant, friction being the only appreciable force acting. This assumption is justified by the fact that in all curves a right line can be drawn occuping the mean position of plotted points. The first point in curve is obtained by substitution in the generally accepted formulas

$$W_1 V_1 = \left(w + \frac{\pi}{2}\right)v, \qquad (1)$$

$$W_1 X_1 = \left(w + \frac{\pi}{2}\right)x, \qquad (2)$$

previously translated. The right line representing mean velocity curve after powder gases cease to act is drawn first. From it the velocity of bullet at from 30 to 40 feet from muzzle is obtained and used in Eq. (1) to obtain V_1. With first point thus established it remains only to draw a curve which shall pass through it, take the mean position of intermediate points, and be tangent to the right line already drawn. The ordinate and abscissa of point of tangency give maximum velocity of recoil and the corresponding recoil. The formula given by Sébert and Hugoniot (Construction Note No. 62, page 10) can be used when the velocity is approaching a maximum very slowly (Curve No. 5, Plate II); but for small arm curves the graphical method is preferred.

From the adjusted mean velocity curve the values in columns 10, 12 and 15 are obtained.

From column 18, we observe a very slight increase in velocity of bullet for the first twenty feet. It begins to lose in velocity after passing a point about 30 feet from muzzle and thereafter loses at a mean rate of about 7 feet for every 10 feet of range. This loss is greater than the value (about 4.7 feet) given by ballistic formulas for this bullet and range. This was to be expected, for the more rapidly moving gases compress the atmosphere in front of the bullet, and the small wires in target screens offer a slight resistance.

The piece has recoiled only 1".59 when it has its maximum velocity, and 2".345 when the bullet is 20 feet away. It thus appears that the piece is the first to suffer retardation.

The two values of mean velocity for whole range, given by the two instruments, furnish a satisfactory check.

The recoil corresponding to maximum velocity. of recoil, the range corresponding to maximum velocity of bullet and the retardation of bullet over the remaining short range are shown only approximately in the tables submitted. A slight variation in efficiency of powder will materially affect these data.

To determine accurately the retardation of bullet, the photo-chronograph, or the polarizing photo-chronograph referred to in the introduction, should be used.

In investigating free recoil of cannon, it is customary to assume friction to be negligible; but, inasmuch as the negative furnishes the necessary data, it is thought best to obtain at least an approximate correction for loss in maximum velocity of recoil through friction.

The piece is mounted on small iron wheels whose circumferences are grooved to fit the track formed by letting brass rods into longitudinal grooves in top and bottom of wooden box. The weight of piece is supported (Fig. 7, Plate I) by the two lower wheels, front and rear, while the upper wheel keeps the piece in a vertical plane. The tracks can, without sensible error, be assumed as horizontal.

By removing rear of box, Fig. 7, Plate I, and carrying a silk thread attached to rear of piece, over a very light pulley at rear of box, the force just necessary to start piece rolling was measured. The pulley was made from a light clock wheel and, with thread from pulley to piece parallel to track, the force was measured by dropping bird shot into a cup attached to end of thread until piece began to move. The weight of cup and shot was 3600 grains, giving for coefficient of friction

$$\frac{3600}{69225} = 0.052. \tag{3}$$

From curve No. 1, Plate II, we find the velocity of recoil 11.291 f.s. for recoil = 1''.590 and 11.130 f.s. for recoil = 7''.179.

Substituting in the expression

$$F = M \frac{v\,d\,v}{dx}$$

we find the mean retarding force, F,

$$F = 8338.6 \text{ grains.}$$

and the coefficient of friction, μ,

$$\mu = 0.1205. \tag{4}$$

It is held by some authorities* that the coefficient of friction increases with increase of velocity where the pressure is light and velocity moderate.

In this case the increase may be due to abnormal and irregular variations in pressure caused by balloting of piece during recoil, this balloting being due to the fact that the center of gravity of piece (mounted) was 0''.72 below axis of bore, and to the slight vertical play of wheels necessary to prevent binding.

The coefficient of friction is often found to vary even under similar conditions.† For our purpose the coefficient as given by Eq. (4) will be used.

The position of center of gravity of piece was determined by the usual method of suspending it as a pendulum (three points of suspension being used to insure accuracy).

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*See Appleton's Cyclopaedia of Applied Mechanics, Volume 1, page 849.

† See Construction Note No. 56, Part I.

The component of weight supported by front wheel, w', is 4.7139 and by rear wheel, w'', 5.1758 pounds.

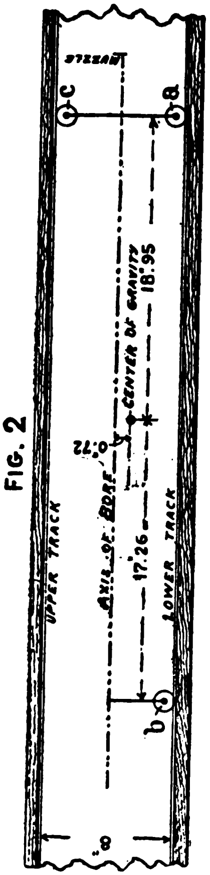

FIG. 2

Let

P = Mean pressure on base of bore during first stage of recoil.

P' = Mean pressure on base of bore during second stage of recoil.

w = Weight of projectile.

π = Weight of powder charge.

W' = Pressure of front wheel (a) on track due to weight of piece = 4.7139 pounds.

W'' = Pressure of rear wheel (b) on track due to weight of piece = 5.1758 pounds.

R' = Reaction of track on front wheel (c) due to moment of powder pressure.

R'' = Reaction of truck on rear wheel (b) due to moment of powder pressure.

x_1 = Distance passed over by piece during first stage of recoil.

X_1 = Recoil corresponding to maximum velocity of recoil.

μ = Coefficient of friction.

E = Recoil energy lost through friction during first stage of recoil.

E' = Recoil energy lost through friction during second stage of recoil.

V_m = Velocity of recoil at exit of projectile.

V_1 = Maximum velocity of recoil from mean curve.

V_e = Maximum velocity of recoil corrected for loss due to friction.

During first stage of recoil we have the following sequence of equations leading up to determination of V_e for this negative:

$$W_1 V_m = \left(w + \frac{\pi}{2}\right) 1266, \tag{5}$$

to determine V_m and thence muzzle energy of recoil;

$$P = \frac{M V_m^2}{2 x_1}, \tag{6}$$

and

$$0.72 P = 18.95 R' + 17.26 R'', \tag{7}$$

$$R' : R'' :: 17.26 : 1895, \tag{8}$$

to find P, R' and R'';

$$E = \mu\,(R' - W')\,x_1 + \mu\,(R'' + W'')\,x_1, \qquad (9)$$

to find E.

$$P' = \frac{M(V_1^2 - V_m^2}{2(X_1 - x_1)}, \qquad (10)$$

and two other equations corresponding to (7) and (8) to find P', R' and R'';

$$E' = \mu\,(R' - W')(X_1 - x_1) + \mu\,(R'' + W'')(X_1 - x_1), \qquad (11)$$

to find E'; and, finally,

$$E + E' = \frac{M(V_e^2 - V_1^2)}{2}, \qquad (12)$$

We find by solution of above equations,

$$V_e = V_1 + 0.060 = 11.351 \text{ f. s.}$$

We are now prepared to use the general equatton

$$W_1\,V_1 = w\,v + A\,\pi,$$

to determine A.

Substituting 11.351 for V_1, 1265 for v and the proper values of W_1, w and π,—69225, 500, and 68, respectively,—we find

$$A = 2254.$$

The errors in measured values of V_1, due to neglecting friction amount to about ½ of 1 per cent.

Corrections are applied before calculating the values of A given in table of condensed data.

The explanations given for Table I, together with the information furnished by headings in following tables (inclusive) will enable the reader to understand the remaining data submitted. The tuning fork used gives 247.76 complete vibrations per second.

CONCLUSIONS.

Energies of Recoil.

1. A black powder charge of 68 grains and a smokeless powder charge of 29 grains give to a 500 grains, 0″.45 caliber bullet, mean maximum velocities of 1279 and 1235 feet per second respectively, and to the piece, mean maximum engeries of free recoil of 20.172 and 16.231 foot pounds respectively.

Assuming that a 29 grains charge from a more efficient lot of Rifleite would give the velocity 1279 f. s. without change in A, the energy of recoil would become 17.086 foot pounds.

The ratio of recoils from black and smokeless powders is therefore, 1.18 to 1.

2. The maximum energies of tree recoil of small arms decrease rapidly with increase of weight of piece.

With weights 8.540 and 11.319 pounds, 0".30 caliber rifle, the maximum energies, for same cartridge, are 11.050 and 8.185 toot pounds respectively.

When weight of piece becomes infinitely great, energy of recoil reduces to zero. When it is desirable to reduce recoil, it may be done by increasing weight of piece.

3. Velocity of bullet increases as weight of piece increases. For 8.540 and 11.319 pounds weight of piece, 0".30 caliber, the mean maximum velocities of bullets, for same cartridge, are 1915 and 1934 feet per second respectively.

In a fixed rest these cartridges gave a mean maximum velocity of 1987 f. s. at 50 feet range.

4. Dynamometer records of energies of recoil are between 60% and 70% of the true energies of free recoil. This illustrates the effect of initial brakes in keeping down the recoil of heavy guns.

Values of Coefficient A.

1. This coefficient is affected by almost any change made in conditions of loading.

2. It decreases with increase in weight of piece, dropping from 2956 for 8.540 pounds to 2690 for 11,050 pounds, weight of piece, 0".30 caliber.

3. It decreases with the charge, dropping from 2258 for 68 grains black powder, to 1716 for 58 grains. A part of this decrease in A is due to increase in weight of piece, which was 9.889 for the 68 grains and 10.963 for the 58 grains charge.

4. It is larger for smokeless powders than for black powders.

5. The coefficient, A, is sometimes defined as the *mean velocity of powder gases*. This definition is inaccurate and is liable to produce the impression that there is such a thing as a *powder* coefficient which in the simple equation

$$W_1 V_1 = w v + A \pi$$

will permit the calculation of the maximum velocity of free recoil, V_1, for *any* value of W_1, w and π, provided the powder for which A was determined be used and the value of v be measured.

The above table shows this to be untrue.

The value of A, determined experimentally, is not applicable to different conditions of loading and to different weights of piece. The above table however will enable the reader to obtain, by applying corrections, an approximate value for A, for given conditions that do not differ materially from tabular conditions.

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TABLE VI.

CONDENSED DATA.

Free recoil of small arm rifles—black and smokeless powder.

PIECES.		CHARGE.		MEAN DATA.									VALUES OF A	
Calibre.	Weight, mounted. Pounds.	Powder, grains.	Bullet, grains.	Number of observations.	Maximum velocity of free recoil. Feet per second.	Approximate recoil, inches; corresponding to maximum velocity of recoil.	Maximum velocity of bullet. Feet per second.	Approximate range, feet; corresponding to maximum velocity of bullet.	Muzzle velocity of bullet. Mean of Boulengé records corrected by ballistic formulas.	Maximum energy of free recoil, $\frac{M_1 V_1^2}{2}$. Foot pounds.	Mean dynamometer record. Foot pounds.	Approximate time consumed in acquiring maximum velocity of recoil.	Bullet velocity from column 8.	Bullet velocity from column 10.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0''.45	9.889	68 DuPont, Black.	500	11	11.456	1.449	1279	20	1274	20.172	12.60	0.01174	2258	2295
0''.45	9.889	29 Rifleite, Smokeless.	500	9	10.276	0.030	1235	20	1242	16.231	11.668	0.00838	3236	3116
0''.45	10.963	58 Dupont, Black.	500	5	8.978	0.645	1179	20	1179	13.735	. . . .	. . . .	1716	1716
0''.30	8.540	42 Peyton Smokeless.	220	5	9.124	0.900	1925	20	1938	11.050	7.132	0.00901	2956	2882
0''.30	11.319	42 Peyton, Smokeless.	. . .	9	6.821	0.570	1934	20	1949	8.185	. . . . .	0.007592	2690	2659

Velocities of Small Arm Bullets for First 100 Feet in Range.

So far as known to the writer, no chronograph in general use has yet proved equal to the task of measuring velocities over the short ranges of 5, 10 and 20 feet, and with sufficient accuracy to determine the *rate of change* in velocity of bullet. When this was attempted with Boulengé instruments, for ranges as great as 50 feet, the data were full of contradictions.

In examining photo-velocimeter records on this point, what has been previously explained must be borne in mind, viz: (1) while bullet is passing over 20 feet of range the velocity of recoil is changing rapidly and errors in calculated velocities of bullet are liable to relatively large. (2) The automatic iron target seems to be slow in producing the secondary spark, and for this reason all velocities affected by the spark from this (No. 10) target are doubtful.

Small arm bullets should be considered as having their maximum velocities at points from 20 to 30 feet in advance of muzzle. They should gain in velocity over this distance, for the bullet is enveloped in gases moving in the same direction and with higher velocity than that of the bullet. The velocity of the light gases is soon reduced by atmospheric resistance, and the bullet on passing out of the gaseous envelope encounters a volume of air of abnormal density. This volume of air, on account of the forward motion imparted to it by powder gases, does not at once retard the bullet in proportion to its density; but when firing takes place in a closed gallery, with the last target near end of gallery, it is evident that the bullet must meet abnormal atmospheric resistance while moving over last one or two target intervals.

It is believed that the photo-chronograph referred to in introduction to this report will enable us to measure more accurately, than has heretofore been done, the change in velocity of projectiles due to atmospheric resistance. It will do this better than the apparatus used in this investigation because the recording surface, instead of being attached to the piece, will be wrapped around a uniformly rotating cylinder.

Many exaggerated claims have been made for non-recoil propties in smokeless powders. They do give equal velocities to bullets, with less recoil, but the decrease in recoil is not the equivalent of reduction in weight of charge since the values of A are found to be higher than for the black powder.

Experimental Investigations of First Stage of Recoil.

Under conclusion 6 of his report on "Development of a Photo-Retardograph, etc.," the writer suggested that satisfactory data on this stage of recoil could be obtained best by use of an instrument that would give a *continuous* and *magnified* curve of recoil as a function of time.

His experience in this investigation has confirmed him in this opinion. A comparison of curve No. 5, *plotted from the mean data of six observations*, Plate II, with preceding curves, which were plotted from the *data of a single* observation, shows the apparatus used here to be equal, if not superior in accuracy, to the Sébert Velocimeter. Compare the relative grouping of plotted points about the mean curves, and bear in mind the fact that the times consumed by the small arm and the cannon in attaining maximum velocities of recoil were about 0.008 and 0.044 second respectively. The difficulty in obtaining experimental data increases very rapidly with reduction in time.

Three or four points, at most, of velocity curves during first stage can be approximately determined for cannon. For small arms neither the Sébert Velocimeter nor the apparatus used in this experiment is able to give any reliable data concerning acceleration of piece during development of maximum powder pressure.

THE SYNCHRONOGRAPH*.

A NEW METHOD OF RAPIDLY TRANSMITTING INTELLIGENCE BY THE ALTERNATING CURRENT. A REPORT TO THE BOARD OF ORDNANCE AND FORTIFICATION.

BY PROFESSOR A. C. CREHORE AND LIEUTENANT G. O. SQUIER.

In a general view of the technical history of the art of telegraphy, statistics show that at the present time, more than fifty years since the introduction of the telegraph, nine-tenths of the telegraph business of the world is transmitted by hand, in substantially the same manner as then. From an electrical point of view one naturally asks why it is, that during this period, which represents more electrical progress than all time previous, the rapid transmission of intelligence has not made more advance.

It is to experiments upon a new electrical system of rapid intelligence transmission and its possibilities, that your attention and consideration are invited. It is not intended to enter into a discussion here of the physical causes which have limited the speed and efficiency of the telegraph, but to acknowledge the great work of Wheatstone, Hughes, Edison, Delaney and others, who have brought rapid telegraphy to its present state of efficiency, and proceed to an explanation of the principles involved in the new system, and an account of the experiments already carried out in developing it. These experiments were conducted at the Electrical Laboratory of the United States Artillery School, Fort Monroe, Va., where the land telegraph and telephone lines were available for the actual trials described.

PRINCIPLES OF THE TRANSMITTER.

It is difficult to treat the subject of transmitters apart from their receivers, as any particular transmitter should be considered in connection with the limitations of its receiving instrument. If we could have a receiver sensitive enough to make a distinct and permanent record of every change in current transmitted over the line, provided the line were so situated as to be free from the disturbing influences induced by external causes, it would be ideal; and the discussion of transmitters would be simplified by reducing the elements to the line and transmitting instrument alone. The qualities of receiving instruments include two principal elements. They all require a certain amount of energy to operate them, and in addition, most of them have inertia in the moving parts. A distinct advance is made, other things being equal, in the receiver which dispenses entirely with the inertia of moving parts. This is accomplished by electrolysis in the chemical receiver of Bain, which has recently reached great perfection in the hands of Mr. Delany. It is also accomplished in the polarizing receiver which was used in experiments described later.

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* A paper presented at the 115th meeting of the American Institute of Electrical Engineers, New York and Chicago, April 21, 1897.

Transmitters for sending intelligence over electrical circuits are, in every case, instruments which operate to change the strength of the current employed in the line. This includes the telephone, in which the current is a succession of waves differing not only in the frequency with which they occur, corresponding to the loudness, but also as to the shape of the waves corresponding to the timbre or quality. The human ear is such a delicate and wonderfully constructed receiver, that it readily translates this complex wave into intelligence. If a physical instrument could be found which would write out in visible form the exact shape of these telephone waves received, the eye might also be educated to translate them. A perfectly trained eye could detect the difference between the same words spoken by different individuals as the ear now does. Even though the waves might be accurately reproduced, the simpler the waves the less the difficulty of translating them.

The inherent distinction between telephony and telegraphy is mainly that, whereas the telephone utilizes both the frequency of the waves and their form, telegraphy relies entirely upon the duration, number, and order of arrangement of these waves, and not their form. The art of telegraphy is practically limited in this respect to three elements, or their combinations, namely, varying the duration of the waves or pulses, the direction of them, their order of arrangement, or the different combinations of these. Considering these elements separately, the first one, using waves of different duration alone for each character upon the line is not at present used. The last method, a combination of variable duration and order of arrangement of waves, comprises the system of Morse and others so universally used, and includes the more rapid system of machine telegraphy due to Wheatstone.

There are reasons why any system using waves of different duration is not as simple as one which uses waves of equal

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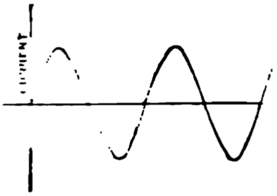

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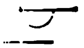

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for transmitting considerable amounts of power over long distances, and the whole system is periodically subjected to a regular and uniform succession of waves rising gradually from zero to a maximum, and then gradually decreasing, reversing, and increasing to a negative maximum. Recognizing these facts, it seemed probable that it would constitute a good means for the rapid transmission of intelligence, if the characters of a telegraphic code could be impressed upon such a current without seriously affecting its regular operation. It is to the consideration of a system of rapid transmission of intelligence by the use of the alternating current that we invite your attention.

Let the sine curve, Fig. 1, represent a regular succession of simple harmonic current waves given to the line by an alternating current generator. If the current passes through a key which may be opened or closed at pleasure, then, provided the key previously closed is opened at a time corresponding to the point P of the wave upon the horizontal axis, it is known that the current which was zero at the instant the key was opened, will remain zero thereafter, in circuits which have received resistance and induction alone. Again, if the key could be closed exactly at a time corresponding to the point Q on the curve also upon the axis, the current will resume its flow undisturbed according to the sine curve. The true current obtained by opening the key at P and closing it at Q is shown in Fig. 2, where the current remains zero between these two points. If the key had been closed at any other point than Q, as at R, the current would not have resumed its flow according to the simple sine wave; but, it can be shown, would follow the heavy curve of Fig. 3, and give a succession of waves alternately smaller and larger than the normal

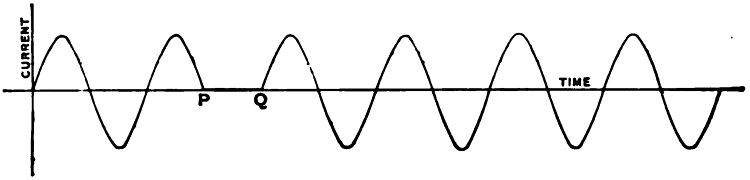

FIG. 2.

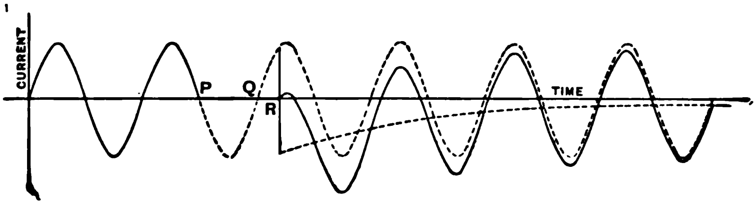

FIG. 3.

sine wave until after a very few alternations, when it practically coincides with the sine wave. In like manner if the key is opened at some other point than P, when therefore the current is not at zero, a spark may be observed at the break, and it requires time for the current to fall to zero.

Let us consider the advantages of thus operating upon an alternating current. It is evident that the advantages above mentioned of using a system subjected to a perfectly regular alternating electromotive force, and capable if necessary of transmitting considerable amounts of power, are by this method made available. In addition, no spark is made in a transmitter adjusted to break the circuit at the exact times indicated by the curve above, when the current is naturally zero. This makes it possible, if it is found desirable, to use comparatively large electromotive forces and currents on the line, for no matter what the maximum value of the current, it is made and broken by this plan with no sparking. It is also possible to employ waves of high frequency upon the line, the upper limit obtainable from an alternator being probably much higher than can be transmitted over the line.

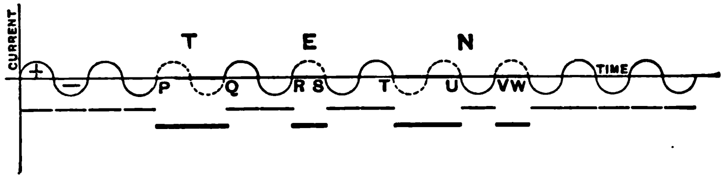

FIG. 4.

If a receiver were used which could reproduce an exact trace of the actual waves sent over the line, it might resemble such a combination as that represented by the heavy curve in Fig. 4. The sine wave continues uninterrupted to the point P when the key is opened, and it is held open for one complete wave-length P Q, when it is again closed for a wave-length Q R; then opened for one-half a wave-length R S; closed for a wave length S T; opened for a wave-length T U; closed for half a wave-length U V; opened for half a wave-length V W and finally closed. By this plan it is possible to use the ordinary Continental code in telegraphy, a dash being indicated when two successive waves, a positive and a negative one, are omitted by keeping the key open, and a dot meaning where a single half-wave is ommitted. The space between parts of a letter, as between the dash and dot of the letter "n" is indicated by the presence of one-half a wave-length, and the space between letters, as between "t" and "e" in the word "ten," by the presence of two half-waves, while the space between words may be represented by the presence of three half-waves, and between sentences of four half-waves or more. The above is a single example, of which there are many, of a method by which the alternating current is made apparent, because it shows how these signals may be interpreted by a fixed code. It need not be said that there are other ways easily devised of interpreting the possible combinations of waves which may be sent in accordance with any code, and it is not our present object to present a method which is deemed superior to others, but merely to show that the above plan becomes operative.

A consideration of the time required to send the word "ten" by the above plan shows that it corresponds to the time of eleven half-waves of current. If we suppose that the frequency is an ordinary one used in alternating current work, viz., 140 complete waves per second, the time required to send the word "ten" is .0394 of a second, or, by allowing three additional half-waves for the space between the words, the word "ten" would be sent just 1200 times in one minute. There is no difficulty in using over some lines, a frequency four times as great as that ordinarily used, namely, as high as 560 or even 600 periods per second. This would correspond to speeds of 4800 and 5143 times sending the word "ten" per minute. The limit in each instance is only determined by the particular line used.

Hitherto it has not been pointed out how it is possible to manipulate a key at the high speed mentioned, so as to open and close the circuit hundreds of times per second as desired at the exact instants when the current is naturally zero. Evidently the proper place to manipulate such a current controller where the circuit must be made and broken at distinct points of phase, is at the generator itself, or in connection with any motor running synchronously therewith.

It will be sufficient for purposes of illustration to show by a special example how any single half-wave may thus be controlled at the generator; for obviously any word or sentence may be formed by a repetition of this operation.

In Fig. 5, S represents the shaft of an ordinary 10-pole alternating current generator which drives through the gears M and N, the wheel W. The circumference of this wheel is one continuous conductor presenting a smooth surface for brushes to bear upon. If the periphery of the wheel is divided for example into 40 equal parts, and it is geared to run at one-fourth the speed of the armature, each division thereof corresponds to one semicycle of the electromotive force produced by the generator.

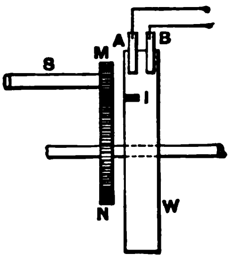

Fig. 5.

Upon the wheel W bear two brushes A and B carried by a brush-holder which is capable of adjustment. These two brushes are connected in series with the line, so that the current which passes in at one brush, is conducted through the wheel to the other brush, and thence to the line. The current used may be obtained from the generator, the shaft of which is represented at S, either before or after it has passed through any number of transformers, since it is the frequency alone with which we are concerned.

The line current is brought to the wheel W to be synchronously operated upon. If both brushes remain continually in contact with the wheel, the current transmitted would have the regular sine form represented in Fig. 1, and for each revolution of the wheel there would be 40 semi-waves or 20 complete waves transmitted. If one-fortieth of the circumference of the wheel is covered by paper or other insulating material as indicaed at I Fig. 5, and the brush A adjusted to ride on to and off from this insulation just as the current is changing from one semi-cycle to the next, that is, changing sign, while the brush B is in continuous engagement with the wheel, the semi-cycle represented by the section covered will be suppressed, and without any sparking, even if the potential used is high. In practice, the brush A is easily adjusted to this point by moving it slightly, backward or forward around the circumference of the wheel until the sparking ceases. This adjustment once made, the brush is fixed in position and so remains. In each succeeding revolution of the wheel, this cycle of operations is exactly repeated, and the current sent over the line would resemble that shown in Fig. 2, having every fortieth semi-cycle omitted. It is only necessary to cover other similar sections of the circumference of the wheel in a predetermined order according to a code, to transmit intelligence over the line. The above illustration of the operation of a transmitter on this principle is given for simplicity only, and is evidently far from a practical form of transmitter.

The wheel W in the above example, may have different speeds with respect to the generator shaft, the essential condition being that its circumference shall contain some integer number of a unit, which is the arc upon the circumference of the wheel if geared to the armature, that a point fixed with respect to the field would describe upon it during one semi-period of the current. This wheel therefore might be connected to any shaft which runs in synchronism with that of the generator, as for instance that of a synchronous motor if the power was obtained from a distance.

Instead of using insulating papers situated upon a single circumference of the wheel, two or more similar lines may be used either upon different circumferences of the same wheel or upon different wheels, and separate brushes ride upon the different circumferences. The same frequencies of current may be employed to operate all lines of brushes, or currents having different frequencies may be employed upon the separate circuits, all of which use the same line for transmission. These arrangements make it possible either to send different messages simultaneously over the same line employing a single cycle as the unit, or to send a message employing different frequencies to represent the different characters of a code, or many combinations of these.

The employment of alternating waves of different frequencies upon the same line by the method shown, does not have the same objections which exist when a constant electromotive force is used. Since the circuit is by this system always interrupted when the current is naturally zero, the frequency employed is within certain limits a matter of indifference as the line is in the same condition whether a long or a short wave is used.

It is seen that by this simple method of operating upon the alternating current, according to the above principles, there is complete control of the individual semi-waves of the current, which may be changing direction thousands of times in a second, far beyond the range of possible manipulation by hand. In other words it is easy to obtain a record of any pre-selected order or succession of semi-waves desired. It is evident that it is as important to be able to control the semi-waves retained, as it is those suppressed, since they are of equal value in interpretation. Furthermore there is great utility in being able to control *each single semi-wave* of the current, for this permits the maximum speed of transmission of signals with a given frequency.

A transmitter which operates upon the current at intervals comparable with the duration of a semi-wave, but which does *not* act in synchronism with the current, would necessarily make and break the circuit at times when the current is not naturally zero. If this were done there would not only be sparking, but in addition, the current would be interfered with in such a manner as to make it probable that the record received could not be interpreted ; for the current at each make would follow such a curve as that shown in Fig. 3.

PRINCIPLES OF RECEIVERS.

As used throughout this paper, the term "receiver" will be understood to mean that mechanism which uses the energy transmitted over an electric circuit, and transforms it so as to make a permanent record which may be translated into intelligence. The term receiver is here restricted to mean instruments which make a permanent record, since this is a necessary condition for the rapid transmission of intelligence, with which we are at present concerned. All receivers require a certain amount of power to operate them, and the power required affords one basis for their classification.

Another method divides receivers into two classes, those which have inertia in the moving parts and those which have none. There is no fundamental reason why any one of these general classes should contain all of the most rapid receivers. Any of the above classes might include receivers which are very rapid. If, for instance, a receiver has inertia in the moving parts, for rapidity the amount of inertia should be small, and its natural period high, or a large moment of energy would be required to operate it. If a receiver has no inertia in the recording mechanism, then the possible rapidity is limited by the power supplied.

In deciding upon the relative merits of receivers from the point of view of rapidity, the cost of the power required offers no reason why considerable amounts of power should not be transmitted over certain land lines for purposes of telegraphy. Using a receiver which possesses much inertia in its moving parts, it does not follow that even though considerable energy reaches the receiver over the line, that it will be rapid in its action.

The Wheatstone receiver may be taken as representative of a type of receivers possessing inertia in the moving parts, which has come into successful operation. The record is made in this instrument by a small wheel which vibrates back and forth between an ink surface and the recording tape. The energy which is essential, is that required to move this little wheel and the parts connected with it back and forth. Although considerable energy may possibly be sent over the line and be expended in the instrument, it seems impossible to concentrate more than a certain part of it upon the moving mechanism. This suggests two methods of improving the speed of the system ; either to increase the power received by the moving parts, or diminish their moment of inertia. One factor which limits the Wheatstone type of receiver is that the moving parts are required to do the work of making the record. This is not a necessity, since light may be employed as the agent to make the record under the control of the moving parts, as is evidently accomplished in a form of galvanometer having a very minute needle with mirror attached, the slightest motion of which is greatly magnified by the reflected beam of light.

As a type of instrument having no intertia in the recording mechanism, may be mentioned the various forms of chemical receivers acting by electrolysis. This type of receivers possesses many advantages, perhaps chief among which is the fact that a large part of the energy received is brought directly to bear upon making the record. Another feature is the simplicity of the essential mechanism involved, as no intermediate steps are employed after the impulse is received from the line before the record is made. These qualities alone imply rapidity, and this receiver is one of the most rapid known. The limit of rapidity with this receiver is the power received from the line. If the potential between the terminals of the receiver is increased, the time required to make a given record is correspondingly reduced. The use of the alternating current permits of greater potentials being realized in the receiver with less disturbing influence from the line than would be the case if a constant direct electromotilve force was employed.

A new type of receiver having no inertia in the recording mechanism was used in developing the transmitter described in these experiments. This instrument has already proved of value as a chronograph for the measurement of minute intervals of time, and for the study of any kind of variable electric currents. Although its application as a practical telegraph receiver is not at present advocated, yet the realization of a *massless* receiver upon different lines merits description. This receiver is based upon Faraday's discovery of a direct relation between light and electricity.

This discovery was, that if a beam of polorized light is passed through some substance in the direction of the lines of magnetization within that substance, there is a rotation of the plane of polarization in a direction which is the same as the direction of the current required to produce such a magnetic field. The direction of rotation is unaltered, therefore, whether the light beam advances in the same or in the opposite direction to the magnetization, so that a beam reflected back and forth through the substance several times, has its rotation increased by equal amounts each time. If the direction of the ray of light is at right angles to the lines of magnetization, there is no rotation produced. The amount of this rotation has been investigated by Verdet, who announced laws by which it may be expressed. They are summed up in the following statement:

"The rotation of the plane of polarization for monochromatic light is in any given substance proportional to the difference in magnetic potential between the points of entrance and emergence of the ray;" that is, it is equal to a constant times this difference of potential and is expressed by the formula

$$\theta = v\ V,$$

where θ = angle of rotation, V = difference in magnetic potential, and v for a given wave-length is constant in any one substance and is known as Verdet's constant.

The following example will make more evident the application of Faraday's discovery to this receiver. Admit a beam of ordinary light through a small aperture into a dark room and let it fall upon a white screen. Suppose that the aperture which admits the beam is provided with a shutter which may be opened or closed at will. We have in this simple arrangement all the essentials of a transmitter and receiver of intelligence. A person opening and closing the shutter might communicate with a second person observing the screen, which would become light and dark at intervals in accordance with a pre-arranged code. Substitute for the first person in direct control of the shutter an electromagnetic device, operated from any desired distance through an electric circuit, and the effect upon the screen is the same as before. For rapid transmission it would be necessary to substitute a mechanical transmitter which would operate faster than a person can send by hand. There would be no particular difficulty in thus moving the shutter more rapidly than any observer could read from the screen. It then becomes necessary to make a permanent record, which may be accomplished by substituting for the screen a self-recording surface having a relative motion across the beam. This is afforded by using any surface sufficiently sensitive to light, many varieties of which are available. In fact a surface is available which is so sensitive that it will record much faster than the *material shutter* can be moved back and forth so as to open and close the aperature.

The next step in increasing the speed, provided the limits of the transmitter have not already been reached, is to secure a more rapid shutter. It was with this object in view, to obtain a *massless shutter* that Faraday's discovery was used. Instead of passing the light directly through the aperture, it is first passed through a Nicol prism in order to obtain a beam of plane polarized light, or it may be polarized in any other suitable manner. Suppose that a second Nicol prism like the first is placed in the path of the polarized beam. If the second prism known as the "analyzer" is turned so that its plane is perpendicular to that of the first prism known as the "polarizer," all the vibrations not sorted out by the polarizer will be by the analyzer. In this position when the planes are perpendicular to each other, the prisms are said to be "crossed," and an observer looking through the analyzer finds the light totally extinguished as though a shutter interrupted the beam. By turning the analyzer ever so little from the crossed position, light passes through it, and its intensity increases until the planes of the prisms are parallel, and if one of the prisms is rotated, there will be darkness twice every revolution. In order to accomplish the same end that is obtained by rotating the analyzer without actually doing so, the following plan is adopted: Between the polarizer and the analyzer is placed a transparent medium which can rotate the plane of polarization of the light, subject to the control of an electric current, without moving any material thing. The medium used in this receiver is liquid carbon bisulphide contained in a glass tube with plane glass ends. There are many other substances which will answer the purpose, some better than others. This was selected because it is very clear and colorless, and possesses the necessary rotatory property to a considerable extent. It only possesses this property, however, when situated in a magnetic field of force, and the rotatory power is proportional to the intensity of the magnetic field. To produce a magnetic field in the carbon bisulphide, a coil of wire in series with the line from the transmitter is wound around the glass tube. When the current ceases, the carbon bisulphide instantly loses its rotatory power. The operation is as follows: First the polarizer and analyzer are permanently set in the crossed position, so that no light emerges from the analyzer. A current is sent through the coil around the tube. The plane of polarization is immediately rotated. This is equivalent to rotating the polarizer through a certain angle, and hence light now emerges from the analyzer. Break the current, the medium loses its rotatory power, and there is again complete darkness. This arrangement makes an effectual shutter for the beam without moving any mass of matter.

This illustrates how Faraday's discovery may be utilized to replace the electromagnetic shutter in the above example by a massless shutter, which enables the current waves sent over the line to be recorded upon the sensitive surface without moving any material thing. An advantage of this receiver is that the speed is not limited by the receiver but only by the natural properties of the line or of the transmitter. Used in connection with the transmitter already described, the real limit is found to be in the line itself.

An analysis of this receiver shows that the energy received over the line is not used directly in making the record, but the agent which makes the record is the beam of light which derives its energy from a local source. The energy received from the line merely controls this local energy which may have considerable power behind it. This controlling phenomenon is one of the few known cases where electricity acts directly upon light. The mechanism by which this action is effected is not at present known, and any experimental evidence upon it would increase our knowledge of the connection between ether and ordinary matter, as well as the constitution of the matter itself. The use of this direct influence of electricity on light makes the speed of transmission through the receiver comparable with the velocities of these agents.

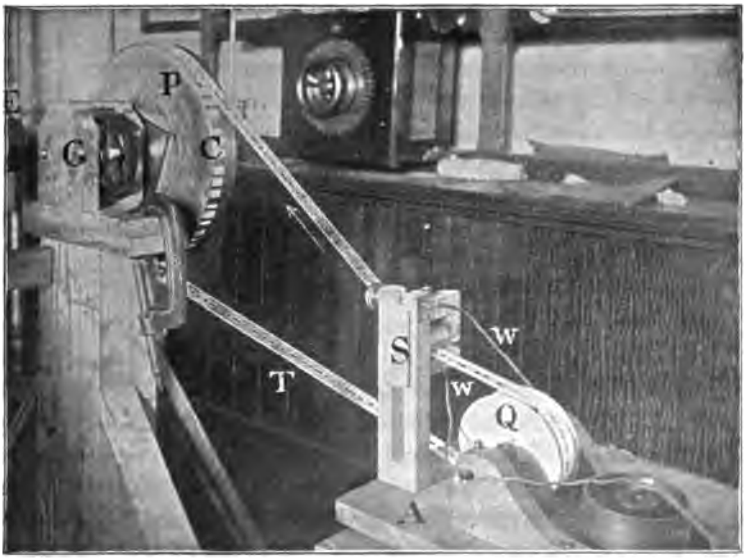

Fig. 6.

DESCRIPTION OF THE TRANSMITTER USED.

In these experiments, the operation upon the alternating current according to the principles already stated, was accomplished by means of a prepared perforated paper tape, which was caused to move by the generator itself. A view of this tape, showing a method of operating upon the current is given in Fig. 6.

The line current is brought through the wires WW to two brushes BB' not shown in the view, held by the adjustable support S. The plan of the brushes is shown in Fig. 7. One brush B bears upon the tape from above, and the other brush B' bears from below immediately opposite the other brush so that they will meet through the perforations in the transmitting tape T. When the brushes meet through the perforations in the tape, the line circuit is closed, and when paper passes between them, separating the brushes, the line circuit is broken.

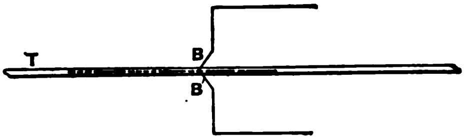

Fig. 7.

It is so arranged that the brushes pass off from, and on to the paper, thus making and breaking the circuit, at the instant corresponding to the points in the current wave, Fig. 1, when the alternating current is naturally zero. The tape T passes over a wheel P geared to the generator shaft, so that for one revolution of the armature, the tape advances a fixed distance. If the generator has ten poles, this fixed distance on the tape corresponds to five complete waves or ten alternations or semi-cycles of the generator current. One-tenth ot this fixed distance corresponds to one alternation or semi-cycle of the current, and may be taken as the unit of distance in perforating the tape. If therefore a hole is made in the tape equal in length to this unit, and the brushes B and B' happen to pass off from the paper so as to meet through the hole at the instant the current is naturally zero, then they wiil pass on to the paper again, breaking the circuit at the next following instant when the current is also naturally zero, since the length of the hole corresponds to one semi cycle of the current.

Suppose that a succession of these unit holes is made, the tape between the holes being also of unit length, then the circuit will be made and broken as by the first hole at the points of zero current. In pactice it would probably not happen that the brushes were at first so situated as to pass off from and on to the paper at the instant the current is zero. In this case a succession of sparks appears, one each time the brushes pass on to the tape and by moving the brushes along the tape it will be observed that this spark either increases or decreases in intensity, according to the direction moved ; but at regular intervals, equal to the unit mentioned above, it disappears. This position of the brushes for no sparking is easily found by trial, and once obtained remains fixed. By this simple practical operation which experience shows requires but a moment to accomplish, the essential condition of synchronously operating upon the current in the manner described is secured. The brushes once adjusted always so remain, and since there is no sparking, it is possible to use high electromotive forces upon the line without injurious effect upon the brushes and tape. It is also plain that this method of operating upon the current is not affected by the speed of the generator, since the transmitting device is always in synchronism with the generator, whatever the speed. The speed of the generator, and consequently the rate of sending, as far as the transmitter is concerned, can be varied at pleasure between wide limits, without any effect upon the synchronous operation described.

An example, giving the data from an early experiment, will illustrate how this is accomplished. The generator was a Fort Wayne 10-pole alternator giving a potential at its terminals of 1,000 volts. This was transformed to about 300 volts, being convenient to handle, and sufficiently high for the purpose. The end of the shaft E, Fig. 6, of the generator carries a small pinion, which engages the gearing G, and revolves the wheel P once in every 18.4 revolutions of the armature. This makes the $\frac{1}{184}$ part of the circumference of the wheel P correspond to one semi-cycle of the current. The circumference of the wheel was about 100 cms., and the length of a unit, therefore, $\frac{1}{184}$ of this, or 0.54 cms.

For convenience, a tape made of ordinary paper had its two ends joined so as to make a continuous belt, which made it possible to use it repeatedly. The tape passed from the large wheel P to the loose pulley Q mounted upon a base-board A, and under the guiding pulley attached to the support S which controlled the tape, immediately before passing the brushes B B′.

In preparing the tape, the Continental code was employed as described, the ommission of two half-waves meaning a dash, and one half-wave a dot. Having obtained the length of a unit on the wheel, the tape is first divided into these equal units, and then the proper units are cut out to form a message. The units which are not cut out form the dots and dashes. To use a continuous tape it is necessary for its length to be some exact multiple of the unit, in order that it may start on the second revolution exactly as it did the first.

The generator current of high potential passed directly through the primary of a transformer, and the secondary was used as the source of electromotive force for the line. This secondary circuit which includes the line was brought to the transmitter to be operated upon as described.

A diagram of the electric circuits as employed in this experiment is shown in Fig. 8, where A represents the alternator, T the transformer, B the brush bearing upon the transmitting wheel W, and L the line. Another diagram illustrating how the method may be used with currents of the same or different frequencies, is given in Fig. 9, where several generators A_1, A_2, A_3, etc., are represented upon the same shaft, and each is connected to a separate brush B_1, B_2, B_3, etc., bearing upon the wheels W_1, W_2, W_3, etc., upon a common shaft and connected to the line. By placing the insulating papers in the proper positions upon the wheels, it becomes possible to transmit in succession, first a current of one frequency and then of another, or of all at the same time.

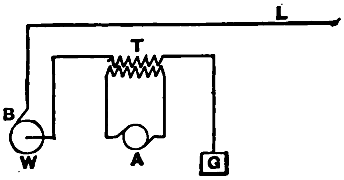

Fig. 8.

If any error is made in laying off the units upon the tape, or if the length of the tape changes in any way after they are accurately laid off, the effect of this error is cumulative from period to period, and although at any particular time the tape might be in phase, sometime later it would not be so, and sparking would occur. This would also be the case if there were any slipping of the tape around the wheel P. To overcome these difficulties it is only necessary to have holes punched at regular intervals in the tape which engage in pins at corresponding intervals on a wheel made to receive it.

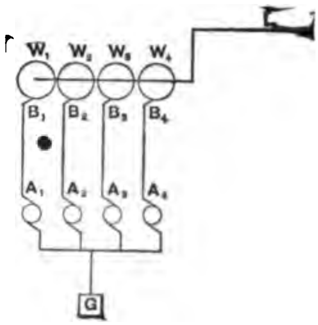

Fig. 9.

A simple experimental method which does away with the necessity of making pins to feed the tape, is to glue strips of thin paper, seen at C, Fig. 6, having lengths corresponding to the paper intervals of the tape, that is, one unit for a dot and two units for a dash, upon the circumference of the wheel P, which has a smooth polished metal surface.

One brush is continually in contact with the wheel, and the other rides on to and off from these paper strips, making and breaking the circuit at the zero phase of the current. The length of message permitted, is limited by the number of units in the circumference of the wheel, which in the example taken was 184.

Instead of using any gearing, as in the example given, to reduce the speed of revolution of the wheel P, the tape might be run directly from a small wheel upon the armature shaft. The unit on this small wheel is one-tenth of its circumference, if there are ten poles to the generator, so that any message sent by fastening papers upon this wheel would be limited to ten semi-cycles. If a single unit of this small wheel is covered by paper, and the brush adjusted for no sparking, one semi-cycle in every ten will be omitted. A record obtained in this case with the polarizing receiver is shown in the circle at A, Fig. 10, in which each light spot corresponds to one semi-cycle of current, and it is seen that one in every ten is omitted. The record in the circle B of the

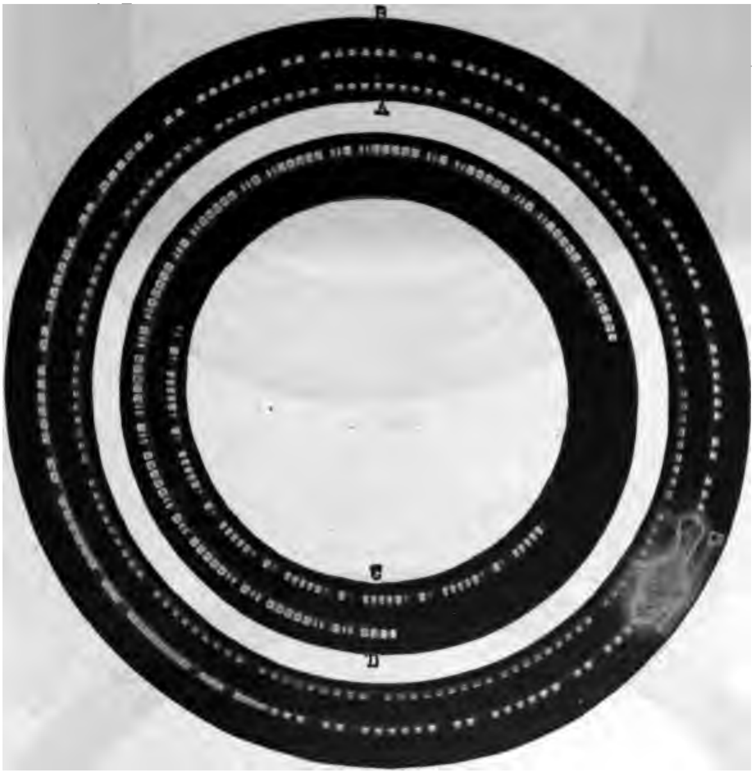

Fig. 10.

same figure was obtained by using two units of paper on the same wheel, having two units between them, and shows that two semicycles are omitted in every ten.

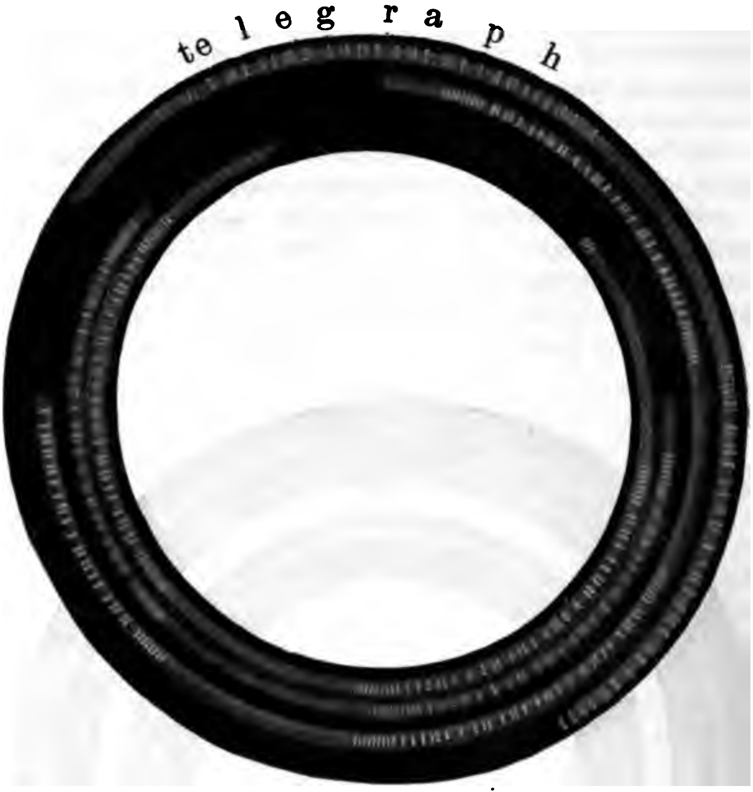

Fig. 11.

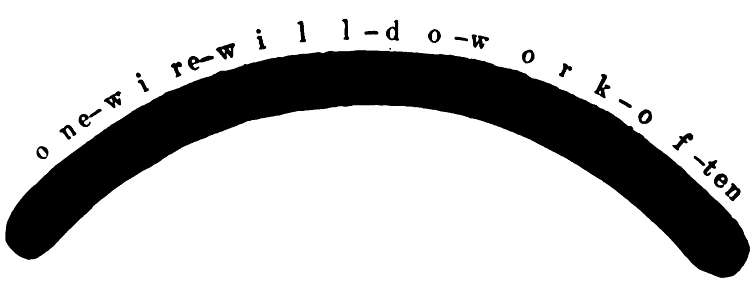

Fig. 12.

Polarizing Photo-Chronograph Record. Message sent at Fort Monroe, Va., August 10, 1896, rate of sending is about 1200 words per minute. This particular message sent in one-half a second. The number of "dots" per second is 337. Continental Code is used.

Records obtained by the use of paper fastened upon the large wheel P, Fig. 6, are shown in Fig. 11, where it is seen that the word "telegraph" was transmitted. A record obtained by the use of tape is shown in Fig. 12, where the sentence "one wire will do work of ten" was transmitted on August 10, 1896. This message was sent at the rate of 337 semi-cycles of current per second, thus requiring about half a second altogether.

Since the speed of transmission depends upon the frequency of the alternating current, the limit of speed is determined by the particular alternator used. In the above example the alternator available was designed to run at a speed of about 1600 revolutions of the armature per minute, corresponding to a frequency of 133, or 266 alternations per second. To increase the speed of transmission, this alternator was run as high as 2400 revolutions per minute, beyond which it was thought dangerous to go. This corresponds to a frequency of about 200 complete cycles or 400 alternations per second. Through the kindness of Dr. M. I. Pupin of Columbia College, a special high-frequency alternator was loaned for the purpose of testing this system at higher speeds of transmission. This alternator, shown in Fig. 13, is in fact four alternators upon the same shaft, having 18, 22, 26, and 30 poles respectively. To obtain the highest speed, the 30-pole machine was used, and the transmitting wheel geared to the shaft as with

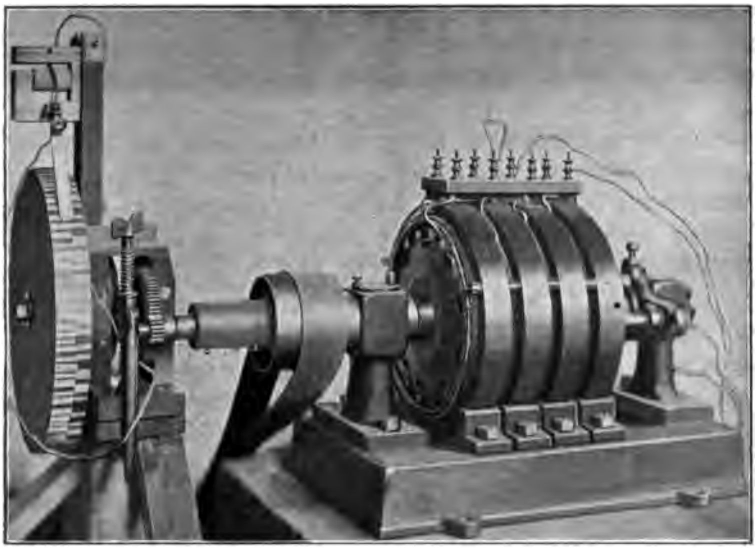

Fig. 13.

The Pupin High-Frequency Alternator, attached to Synchronous Transmitter.

the ten pole alternator. The speed of armature used was 2180 revolutions per minute, corresponding to 1090 semi-cycles per second, or 65,400 per minute, or a frequency of 545. No difficulty was experienced in sending and recording messages at this rapid rate which corresponds to between three and four thousand words per minute.

THE POLARIZING RECEIVER.

The statement of the general principles employed in this receiver has previously been given, and it remains to describe the actual form. This instrument was designed for a military chronograph to measure the velocity of projectiles, and is known as the Polarizing Photo-Chronograph.* A view of this is shown in Fig. 14.

Without giving a complete description of the instrument, which may be found in the reference cited, it will suffice to describe its essential elements. A sensitive photographic plate 12x12 inches square is carried in a metal plate holder, which revolves in the wheel w driven by the motor m. A powerful beam of light from the arc lamp, A, situated upon an inverted T-rail, O′, serving as an optical bench, is condensed by the lens L, and passes through the polarizer P, a Nicol prism, thence through the glass tube T, containing liquid carbon bisulphide, and surrounded by a coil of wire, through the analyzer A, a second Nicol prism. The light received through the analyzer is finally passed through a second lens L′ to focus the beam upon the horizontal radial-slit in front of the moving sensitive plate. In its operation, the analyzer A is rotated until the light is completely extinguished, when no current is passing around the tube T. The coil upon the tube is in circuit with the line from the transmitter, and the closing of the circuit at the transmitter thus sends a current around the tube, and light immediately appears upon the camera slit. This is accomplished instantly upon closing the circuit, without involving the motion of any material thing. Upon breaking the circuit the light immediately disappears, and by observing the light come and go, it is easy to read with the eye as rapidly as can be sent by hand. To produce a permanent record it is only necessary to rotate the photographic plate in the wheel w. The time required by the photographic plate to make a clear record, depends largely upon the intensity of the light; but the intensity of light which it is practicable to obtain allows the time of exposure to be much shorter than is required for the purpose of a telegraph receiver. For instance, suppose the

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* "The New Polarizing Photo-Chronograph," Crehore and Squier. John Wiley and Sons, New York, 1897. Chapman and Hall Ltd., London.

ting current with the single needle and plate as electrodes, the record shows a regular succession of distinct marks, separated from each other by equal intervals. Each mark exhibits an intensity varying approximately according to the sine curve. Since by this arrangement the current makes its record in one direction only, the result is that alternate semi-cycles of the current are suppressed, and alternate ones are recorded.

By receiving with two needles side by side, all the alternations are recorded, those that were suppressed before now appearing at the second needle. The record then appears as two parallel lines of marks having the maximum intensities in one line opposite the space in the other. Using the transmitter as already described with a semi-cycle as a unit in preparing the tape, and receiving in two lines, it is found that some of the marks are omitted in one line and some in the other, and to facilitate translating it is simpler to bring the two lines into coincidence to observe the dots and dashes of the message. A message was then prepared upon the transmitter wheel, using a complete cycle as a unit, instead of a semi-cycle. When received in a single line this message is complete, no matter to which terminal of the circuit the receiving needle is connected, because each unit now contains both a direct and a reversed current, one of which will record.

The same message was then received in two lines, and one line gave the complete message as before, while in the other line there appeared a record for each complete unit in which the current was made. The papers of either the first or the second half of each complete cycle composing the message upon the wheel were next removed, and the message received in two lines as before. The result showed the message complete in one line, while in the other line appeared an uninterrupted succession of marks just as given by the simple alternating current received in one line.

If then an uninterrpted line of marks can be received in one line at the same time that a message is being received in the other, this uninterrupted line can be used for a second message entirely independent of the first. The next experiment accomplished this, and it is now possible to use the same line to send two entirely independent messages in the same direction at the same time at a high rate of speed. The preparation of the transmitting tape to accomplish this, simply requires that the two messages, each prepared with a double unit, shall be displaced a semi-cycle with respect to each other as they pass through the transmitter.

S

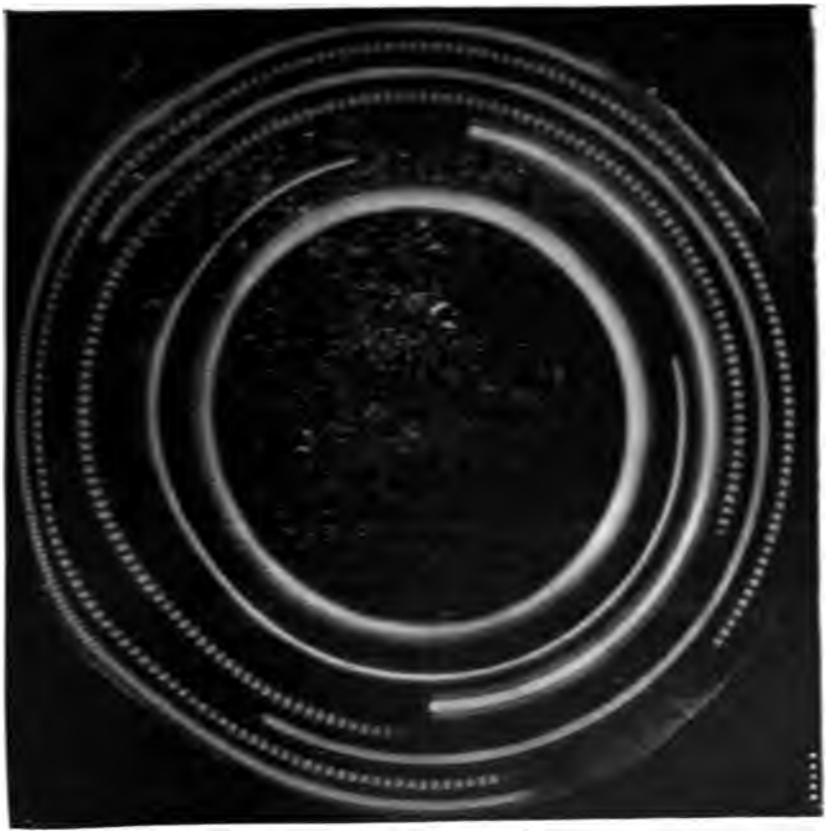

Figure 15.

CHRONOGRAPH RECORDS OF THE ALTERNATING CURRENT UNDER VARYING CONDITIONS OF CIRCUIT AND SPEED OF PLATE.

The advantages of duplexing the line, that is, sending two independent messages in opposite directions over one wire at the same time seem more important than those of diplexing the line. An arrangement of circuits which accomplishes this proves to be very simple. Moreover it permits entirely different frequencies to be employed by the transmitters at the two ends of the line, and as before involves no synchronous receiver at either end. By duplexing the line the speed of transmission over a single wire is practically doubled; for example a line that carries 3000 words simplex can carry 6000 words per minute duplex.

It is desirable in many cases to manifold the original copies of the message received, and experiments were made to accomplish this. All that is necessary is to attach to one terminal, instead of a single needle, as many needles as the number of copies desired, having each make its record upon a sensitive surface. The manifolding process evidently applies to either simplex or duplex receiving. Manifold copies of messages may be received in widely different localities at the same time from one and the same transmitter, by connecting the receivers in series or in parallel.

The alternating current is adapted to use with condensers in series with the line where a direct current cannot ordinarily be employed. An experiment was carried out to send a message through a condenser having a capacity of 9.57 microfarads in series with the line, and it was found that the message was transmitted correctly. One object of this experiment was to establish the possibility of using a set of Morse instruments upon the line at the same time that the messages were being transmitted at a high rate of speed by the alternating current. By shunting condensers around the set of Morse instruments it was found that the operation of either system did not affect the working of the other, so that it becomes possible to use the same high speed line for a complete system of quadruplex telegraphy at the same time. Indeed it seems possible that the present Wheatstone system could be operated over the line in conjunction with the alternating current messages. The experiments with the chemical tape which have been outlined above, together with others not here given, demonstrate the flexibility of a system of intelligence transmission employing the alternating current.

The use of the alternating current as a means of sending intelligence in connection with the fact that a message can be sent through condensers, suggests the possibility of using the principles of electric resonance employing circuits having natural periods of their own which will pick out and respond to currents from the line having their own frequency.

Although the above illustrations have employed for the most part the Continental code representing a dot and a dash in a particular manner by the ommission of certain waves, and the spaces between letters and words by the presence of waves, yet it is evident that this is but one of many combinations which this system permits, and that mentioned above is not to be understood as representing the most desirable one.

A characteristic of the records made by electrolysis is the natural separation of the positive and negative waves of current, which is an advantage in interpretation. This separation is also accomplished in the polarizing receiver by employing two receiver tubes. Instead of setting the polarizer and analyzer for extinction they are so placed that some light is normally transmitted through each tube. The tube coils are so connected that a positive current produces approximate extinction in one tube, and a maximum transmission of light through the other. A negative current transmits a maximum of light through the first tube, and produces approximate extinction in the second. An alternating current therefore causes a record of the positive waves through one tube, and the negative waves through the other, and thus accomplishes all in this respect that the chemical receiver does.

THE LINE.

It is generally understood that the line limits the speed of telegraphy. The limit is usually reached because of the distributed electrostatic capacity of the line rather than its resistance. The influence of the distributed capacity is to change the form of the wave as well as reduce its amplitude. With a given length of line having a certain static capacity, there exist limits to the speed obtainable with any given set of instruments which would be a difficult mathematical problem to predetermine. The difficulty in making this calculation is in the influence exerted by the particular instruments used. With different instruments the upper limit of speed is very different with the same line. It therefore seems that the only way to determine this question is by submitting the system to actual trial over a long line.

In order to test this system over as long a line as was available, the land telegraph and telephone lines upon the military reservation at Fort Monroe were joined in series, making about thirteen miles of iron wire having a resistance of 320 ohms. Not only was no difficulty experienced in transmitting and receiving messages over this line, but resistance was introduced making about 1,500 ohms total including the polarizing receiver coil of 390 ohms. This trial was at a frequency of about 200 complete periods per second. With the chemical receiver a coil of 10,900 ohms was used in the laboratory and the record was plainly received at a frequency of about 545 complete periods per second.

Since the polarizing receiver gave indications showing the approximate strength of the varying currents by the intensity of the light upon the plate, it was used to study the effects upon the currents of arbitrarily introducing capacity and inductance into the line, especially the effect upon the make of an alternating current at different points of phase. Fig. 15 shows the general appearance of the simple alternating current with the different exposures, at different speeds of the plate and the same frequency of alternation. In Fig. 10 the inner record C is that of a circuit having 390 ohms resistance, 1.03 henrys inductance, and 4.78 microfarads capacity at a frequency of 137. At each make it is observed that the first wave is small, followed by a large one. The record at D is for a similar circuit in all respects except that the capacity is doubled, being 9.57 microfarads. Theoretical curves* have been computed for these cases and they are in agreement with the records shown.

The method of neutralizing the effects of the distributed capacity of lines by introducing distributed inductance as is now done in some telephone lines, would have an especially useful application in a line employing the alternating current for telegraphy.

CONCLUSION.

When the extent of the transmission of intelligence at the present time is considered, and the direct influence which this service has upon the development of the world's progress, any proposition which promises to increase its efficiency should be received with consideration.

To better comprehend the volume of this service it is of interest to observe the statistics on the subject. These have been prepared for the United States mail service, the Western Union Telegraph Company, and the American Bell Telephone Company of the United States, and are exhibited in graphical form in Fig. 16. The statistics for the United States Mail service for the last few years were furnished through the courtesy of the Postmaster-General.

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* "The new Polarizing Photo-Chronograph"—*Journal of the U. S. Artillery*, Fort Monroe, Va., November-December, 1896.

It is noticed in general, that there is an increase in all departments of the intelligence transmission service from the earliest dates. The number of pieces of mail sent during 1896 was 5,693,000,000 which is the greatest amount ever sent in a single year. The greatest number of telephone messages on record for a single year is 757,000,000 in 1895. The largest number of telegraph messages was sent in 1893 and amounted to 66,000,000. Thus the greatest number of telegraph messages as compared with telephone messages is in the ratio of 1 to 11½. The greatest number of pieces of mail is in the ratio of 86 to 1 as compared with telegraph messages, or in the ratio of 7½ to 1 as compared with telephone messages. It is also seen that the cost of the mail service of the United States in 1896 was $90,626,000, or about $1.25 per capita. The greatest receipts for any year of the American Bell Telephone Company were in 1895 $16,400,000, about 25 cents per capita, while the greatest receipts of the Western Union Telegraph Company were in 1893 $24,978,000, about 35 cents per capita.

It appears therefore that the people of the United States pay for a telegraph service of about one-eighty-sixth the amount, about one-fourth of that paid for the entire mail service of the United States. It also costs one-and-a-half times as much for telegraph service as for the telephone service, although the number of telephone messages is about eleven-and-a-half times as great.

A conclusion to be drawn from the above general data seems to be that the people are willing to pay more in proportion for a kind of service like that of the telegraph than any other. From the point of serving the people, as well as from a business standpoint, it appears that improvement in this class of intelligence transmission is at present much to be desired. The present state of the art of telegraphy points to improvements along the line of automatic machine transmission.

It is of interest to inquire what effects a system of telegraphy capable of sending continuously 3,000 words a minute would have on the existing methods. To take a single example of the business between New York and Chicago, where about 40,000 letters are carried daily, it would require but two lines in continuous operation to handle the entire business. At present it takes three days to receive a business reply between New York and Chicago. This transmission by machine telegraphy could be accomplished easily the same day. It is thought that an effect of this would be to increase business transactions to such an extent that the total volume of intelligence transmitted would be augmented, rather than to diminish the business now done by existing methods.

The class of business which such a system would probably at first obtain would be the less urgent telegraph business of greater volume, such as the Associated Press dispatches and newspaper press reports. Among the possibilities is the simultaneous publication of the same newspaper in different parts of the country. For example, in an edition of a daily paper having twelve pages and eight columns per page, making ninety-six columns in all, there are less than 185,000 words. At the rate of 3,000 words per minute it would only require about an hour to transmit the entire contents of the paper. This calculation furthermore assumes that the whole paper is uniformly printed in fine type. It would require a single operator, working by hand and averaging twenty words per minute, over six days of twenty-four hours each to send this amount.

The system proposed in this paper is especially adapted to meet the demands of this class of business; for the great flexibility of the alternating current as employed, permits if necessary considerable amounts of power to be transmitted over the line which may be used for making simultaneous manifold copies of the same dispatches in each of widely separated cities. In this manner each of the several newspaper company subscribers in each city receives the identical service with the minimum delay, since each copy received is an original. Each additional subscriber to this service represents no appreciable expense to the company, since it requires but another receiving needle. Furthermore, the use of the alternating current permits the line to be used quadruplex at very rapid speeds, that is, four entirely different dispatches may be sent over one wire at the same time, two in each direction, and any number of copies of one or all the dispatches may be received independently at the same time.

In addition to the above it is practicable to employ the line for a system of the ordinary quadruplex telegraphy at the same time. In trial experiments in the laboratory, particular instructions were given to the operator of the Morse instrument to observe if possible when messages were being sent by the alternating current, and absolutely no effect was detected.

The objection may be urged, that it is already difficult to handle the business at the present rate of operation of the Wheatstone system, and if the instruments worked faster it could not be handled. This objection is undoubtedly a real one in some cases, and it is partly this fact which indicates that it may be easier to inaugurate new methods than to attempt to adapt the new rapid transmitters to the present methods.

A telegraph office of the future will probably present a different appearance from that which may now be seen in any of the large cities. At present in operating the Wheatstone system in this country, sending to long distances at the rate of 150 to 200 words per minute, both those who prepare the sending tape and those who translate the receiving tape are employés of the telegraph company and are near the sending and receiving instruments. If it requires about ten men to prepare tape, and as many more to translate it for a single instrument operating at 150 words per minute, it will require twenty times this working force for one of the rapid machine transmitters. Evidently changes would be required in the present methods to handle this business.

It is thought that a telegraph company of the future will fulfil a somewhat different function from the present ones. The company will own its wires and rights of way as now, but the tendency of the offices proper will be to transmit and receive letters already prepared rather than to undertake the preparation of the letters as well. The income of the company will be derived from the rent of its lines at a fixed price per minute, or a fixed price per hundred words. The service of the telegraph office then becomes like that of the post office, its duty being to receive and deliver letters already prepared, as the post office does. The difference between the two offices is in the manner in which this is accomplished. The telegraph office becomes a post office which employs an electric current in a copper wire to carry its letters instead of a railroad train. The advantage in point of speed of delivering letters by the former method is apparent. Instead of requiring twenty-four hours to deliver letters between New York and Chicago, it will require but a few hours at most, and make it possible to receive a reply the same day. It is probable that such a system would take more business from the present postal system than any other; for when telegraph letters can be sent at reasonable rates comparable with postage, in a few hours instead of many days, a certain amount of present post office business will be diverted. More than this, when business can be done with greater facility than at present, the total volume of business will undoubtedly be increased, because transactions may take place in a day which formerly required a week.

It would be to the interest of such a company to seek that class of less urgent business now done by correpondence, rather than the class handled by the present telegraph companies, where the highest speed of delivery is expected. If one trunk line becomes established between large business centers, it will draw business from a surrounding area. For instance, if a line were established between New York and Chicago, and a person in Albany desired to communicate with Chicago or points beyond, it would be quicker to send the letter to New York for transmission over the trunk line to Chicago, and then by rail to its destination, than to send directly by rail from Albany. With a few trunk lines in successful operation it would not be long before they would be multiplied.

It is understood that these telegraph letters are sent by mail in envelopes in the usual manner, except that the envelope contains the prepared message ready to be sent through the transmitter, and thus the telegraph office becomes relieved of the preparation of the letters which is not strictly a part of its business. When the system comes into general use, business offices will have their own perforators, and it will become necessary for the operator to learn the telegraph alphabet as a part of his preparation as a stenographer and typewriter. The three-key perforating machine is comparatively inexpensive, but undoubtedly a machine could be devised at an early date, as an attachment to the present typewriter, for the purpose of perforating letters at the same time that they are being written by the typewriter in the usual way. This could be constructed to operate by the use of electro-magnets, and can be attached to a typewriter without interfering in any way with its operation. No extra power would be required, for this can be derived from an electric current which operates the attachment. The writing may be perforated at the present rate of speed of typewriting without the operator having any knowledge of the telegraph alphabet as far as perforating is concerned. This machine will cost more than the three-key perforator, but it would in a short time more than pay for the difference in cost on account of the great gain in speed, and also because it prints a copy of the letter which may be kept on file. Before these perforators are introduced into common use it will be necessary to establish offices in the immediate vicinity of the terminals of the trunk lines, to prepare letters for persons furnishing printed or written copy, as well as to furnish a printed translation when desired of letters received from the central office. The opportunity to obtain a cheaper rate for prepared letters will act as an inducement to those employing a stenographer to add a perforator to their offices.

Concerning the daily correspondence of the large business houses between cities which are the terminals of the trunk lines, it might be an advantage for them to have exclusive use of the line for a certain number of minutes daily at a certain fixed time of day, by subscribing and paying an annual rental to the company. Knowing definitely at what hour the mail would be dispatched daily, it would then be possible for each house to send by messenger its daily mail already prepared for transmission to the general transmission office, where it could be placed in boxes prepared for the subscribers, to be taken out and transmitted when its time arrives. The distribution at the receiving end of the line could be accomplished as now by the regular mail service.

In the limited use of rapid automatic intelligence transmission at present, the sending and receiving records are made upon prepared paper in the form of tape. In the larger volume of business which is being considered here, it does not seem certain that tape would be the best form for the sending and receiving paper. It would be an advantage to have the letters received upon sheets of paper with the dots and dashes arranged in parallel lines. Besides facilitating the reading, this form would be more convenient for mailing. It would also easily permit reference to any part of the letter at a glance. The amount of paper required by the use of sheet form instead of tape would be reduced, which is an item of importance where such a volume of business is being handled. Sending and receiving from the surface of a cylinder seems entirely practicable.

Another point which must be considered is whether with these systems, the induced currents from neighboring wires along the line or from any other cause will affect the legitimate signals materially, as has been at times the case with the Wheatstone system. In reply to this it can be said that these receivers for telegraphy are not necessarily more senitive to small currents because they are rapid. On the contrary, they may be made to require as much current as is found desirable to rid them of the effects of outside influences, and at the same time retain the property of quick action in response to currents of the proper magnitude. In this connection it may be said that the utility of a single line wire becomes so great that more attention will be given in the future to the line construction and maintenance. If millions of dollars are invested in the construction of a single railroad, is it not as necessary to make the telegraph lines which carry important and profitable business as perfect in their construction?

The telegraph line of the future will comprise substantial poles carrying a few copper wires worked to their full capacity for transmitting electric signals. The cost of maintenance of such a line when once constructed will be little more than for an ordinary iron wire now used, while its carrying capacity for intelligence at 3,000 words per minute simplex will be about equal to 160 wires used for hand transmission simplex. By duplexing the line, the carrying capacity is doubled and becomes 6,000 words per minute, which is about equal to 160 wires worked duplex, or to 80 wires worked by hand quadruplex.

It is thought that the influence which the inauguration of a telegraph letter system would have upon the existing telegraph and telephone business would be to increase rather than diminish it. Each of these services has its own special field of usefulness but little affected by the others. A new field would be occupied rather than an old field supplanted. The present telegraph and telephone would still have their natural field of operation, even though the best hopes for a telegraph letter service are realized.

A single line capable of sending 6,000 words per minute between New York and Chicago, becomes a different kind of investment from a long distance telephone line where the number of words per minute with the fastest rate a speaker can talk is very slow in comparison, and the charge is $9 for five minutes' use of this line.

The application under government control of a rapid system of correspondence transmission such as has been outlined, operating in conjunction with the present postal system, by supplementing and relieving their service could hardly fail to prove of benefit to the people of the United States. This comes within the proper duty of the Post Office Department, and would be under the direct control of the Postmaster-General. The simplification in operation and expense which would result from uniting directly with the general post offices of large cities the telegraph letter service would soon be realized by the people and a better service insured.

As a practical means toward ultimately assuming the direct responsibility of this new service, it would probably be easy to secure private companies which would be willing to contract with the Post Office Department to transmit telegraph letters at a fixed rate for a term of years. In this manner the Department could gradually absorb this branch of its business and be relieved of any sudden new responsibility and radical reorganization.

It is not thought that the development of a rapid intelligence transmission service to the extent suggested could be accomplished before many years, nor indeed that the manner or means of this development should closely follow the lines indicated, but that something analogous to this development seems among the possibilities if not the probabilities of the near future.

The persistent efforts of Mr. Delany and the great system which he has developed are well known, and the ideas which he has advanced in regard to the applications of rapid systems are in the main in accordance with those stated herein.

HISTORY OF THE SEA-COAST FORTIFICATIONS OF THE UNITED STATES.

III. NARRAGANSET BAY.

Roger Williams, the great and good man who initiated the Christian Colony of Rhode Island in 1636, was so just in all his dealings with the native Indian Tribes, that peace and good will reigned for many years within its borders. But, after the beheading of Charles I., the government of England being in a very unsettled condition and much discord existing among the people of the colony, it was ordered, in 1650, that all of its arms should be thoroughly repaired and that each town of the colony should be required to build a magazine.

When a new war broke out between the Narraganset and Long Island Indians, the people of Providence became alarmed by some hostile demonstrations, and, therefore, in 1656 erected a fort on Stamper's Hill. It was so called because, soon after the settlement of Providence, when a body of Indians approached the town in a threatening manner, the inhabitants, by running and *stampimg* on this hill, made the hostiles believe that they were greatly outnumbered. The ruse had its desired effect, the Indians quickly retiring. This fort was probably the first ever erected by the colonists in Rhode Island.

The war of 1664, between England and Holland, during which the Dutch settlements in America were captured by the British aided by the colonists, showed the necessity of sea-coast protection against armed cruisers; hence, in 1666, Rhode Island petitioned the home government to erect fortifications for the defense of Narraganset Bay. The report that a Dutch fleet was on its way, in 1667, to recover New York, produced great alarm in the colonies. Hence the general assembly of Rhode Island took every precautionary measure for defense, and recommended that Newport should mount great guns for its protection; but no permanent fortifications appear to have been then erected.

During King Philip's war of 1675–76, inland stockades and earthworks were constructed, but no sea-coast fortifications.

In 1690, the year in which James II, was defeated at the battle of the Boyne in Ireland, a French fleet having made its appearance off our coast, some of the seaports were put in a state of defense by temporary batteries. No permanent works, however, could have been erected in Rhode Island, for, in answer to the rebuke of the mother country that the colony "had not supplied her quota of men and money in aid of the King," the assembly, in 1696, stated "that the exposed condition of Rhode Island, with forty miles of coast line and three great inlets from the sea *undefended*, had demanded all her strength for self-protection."

The treaty of Ryswick having restored peace to all Europe, October 30, 1697, there seemed to be no pressing necessity for fortifications in Narraganset Bay. This general pacification, however, was of short duration, hence it was deemed prudent to provide for the defense of Newport harbor by erecting an earthwork on Goat Island.*

The Earl of Bellomont, a man of singular ability and strength of character, had been appointed by King William III., March 16, 1697, "to be Governor of the Provinces of New York, Massachusetts Bay, and New Hampshire, and to be Captain-General, during the war, of all of His Majesty's forces, both there and in Connecticut and Rhode Island." The latter colony he visited in 1699, and January 10, 1700, the Lords of Trade made a report to the King on the forts in the plantations, in which they say "Rhode Island being the most important place on the southwest side of Cape Codd, is so situated as to be a very convenient harbor for shipping and security to that part of the Country in case it were put in a state of defense, which *it has never yet been*, by the mean condition and refractoryness of the inhabitants," and "recommend an appropriation of £150 for fortifications for Rhode Island and Providence Plantations."

Doubtless, in consequence of this report, Colonel William Wolfgang Romar, "His Majesty's Chief Ingineer," was sent to examine Narraganset Bay; for June 22, 1700, the Earl of Bellomont says to the Lords of Trade: "I send your Lordships Coll. Romar's memorial (marked H), which I have turned into English,

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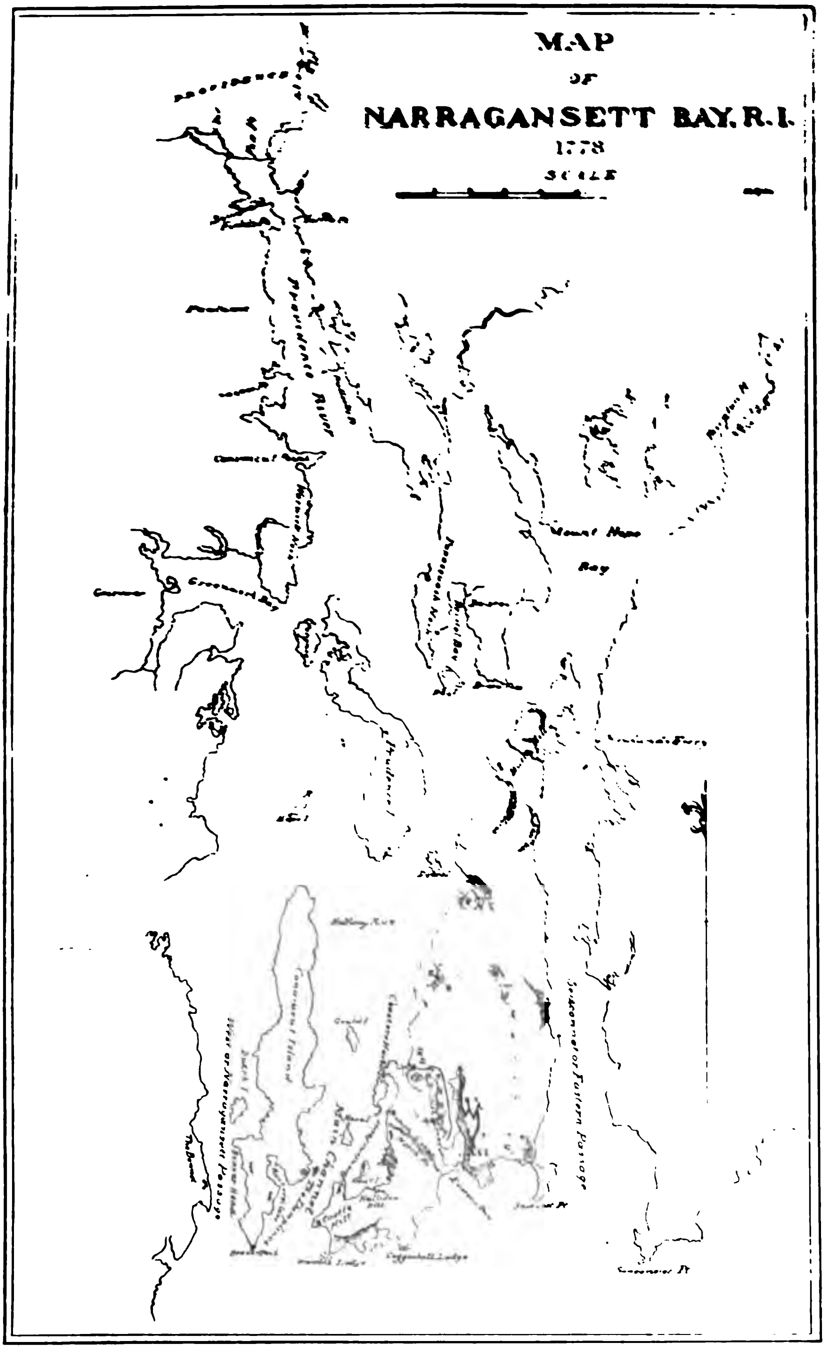
* Cachanaquoat, a Chief Sachem of the Narraganset Indians, sold to Governor Benedict Arnold and James Greene, May 22, 1658, three small islands in the Bay, *Nuntee-Sinunk* alias Goat Island, *Weenat-Shasitt* alias Coaster's Harbor Island, and Dyer's Island, for six pounds and ten shillings. Greene, May 27, 1672, transferred to Arnold his entire claim to enable the latter "to pass over his right in ye sayd two islands (Goat and Coaster's Harbor) unto ye Town of Newport if they will pay him ten pounds in current pay for the six pounds and ten shillings which he disbursed yeares agone on ye acompt." The Town of Newport, May 1, 1673, made the purchase of these islands from Arnold.

The middle part of Goat Island was reserved for the fortifications, and the two ends, containing about ten acres, were laid out in forty-three building lots. After the Revolution (1794) the State of Rhode Island transferred to the United States the existing fortifications and the land occupied by them; and, April 16, 1799, the Town of Newport sold to the United States, for $1,500, the remainder of the island, no payment, up to that time, having been received from the purchasers of the lots on the two ends.

The Breakwater and Lighthouse pier, running from the north end of Goat Island, was built by Captain (now General) Cullum, in 1836-38, and a part of the superstructure and Lighthouse were completed by Lieutenant James L. Mason, of the United States Corps of Engineers. On Henry Jackson's Historical Map in the Redwood Library, Newport, R. I., it is stated that they were constructed by Alex. M. McGregor, who was only the master mason.



wherein he gives so particular an Account of the principal Rivers, Bays, and places fit to be fortified, that there is little to be said or remarked by me."

The small appropriation of £150 for fortifying Rhode Island waters, probably did not supply more than enough for an earthen battery on Goat Island, Newport harbor, the first notice of which is to be found in a bill, passed May 7, 1701, by the assembly of Rhode Island, to sustain the governor in enforcing the navigation act, which provided that "the commander of the fort to be appointed by the governor" should have power to bring to any inward bound vessel by the usual mode of firing "a shot afore her foremast." etc. This small earthen battery (probably thrown up in 1700) the first erected on Goat Island, being found inadequate for the defense of the harbor, a new one was ordered to be constructed, May 6, 1702, by the assembly which enacted: "That for the better defense of his Majesty's interests and good subjects, against the public enemy that shall endeavor to invade or assault his Majesty's subjects in this Collony, there shall be a fortification or battery built at the charge of the Collony, in such convenient place near the harbor of Newport, sufficient to mount twelve pieces of ordnance or cannon." This was a small work, but it must be remembered that the population of the colony did not then exceed ten thousand.

Though "*his* Majesty," William III., had died, March 8, 1702, over eight weeks before this enactment, the news had not then reached the colony. As soon, however, as the new work was completed, it took the name of Fort Anne, after the queen of England, who succeeded William III. Subsequently it was much enlarged by appropriations made from time to time by the assembly. When peace was restored to the world, in 1714, by the treaty of Utrecht, its garrison was disbanded.

Upon the accession of George II. to the British throne, June 10, 1727, Rhode Island voted an address to His Majesty, in which it is stated that "a regular and beautiful fortification of stone with a battery" had been built at Newport, capacious enough for mounting fifty cannons, which His Majesty was asked to supply.* Not till three years later was its name of Fort Anne, which it had borne through two reigns, changed to Fort George, a designation which it retained till the outbreak of the revolution, when, and until 1784, it was called Fort Liberty. This work was completed in 1735, though not fully armed, its cost having amounted to £10,000 in the depreciated currency of the colony.

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* Some of these guns were subsequently supplied through the influence of Sir Charles Wager, who was First Lord of the Admiralty in the ministry of Sir Robert Walpole.

War having been declared in 1739 between England and Spain, the assembly of Rhode Island ordered Fort George to be repaired and furnished, without delay, with ammunition and suitable guns; and, in 1740, watch towers were directed to be placed on Point Judith, Castle Hill, Brenton's Point, Sachuest Point, and "on Conanicut Island," to transmit intelligence of every hostile demonstration.

Soon after, January 27, 1741, pending the second war with Spain and in anticipation of hostilities with France, the assembly of Rhode Island directed the battery at Fort George to be enlarged so as to mount ten or more additional cannon. In 1749, the work was reported to be provided with twenty-five guns in the lower battery and twelve cannon on platforms.

The war of England against Spain and France now extended to both hemispheres, and the colonies were required to do their part on this continent. Rhode Island had her share in the colonial expedition of 1745 against Cape Breton under William Pepperell, afterwards knighted for his brilliant capture of the strong and costly fortress of Louisburg. The year after, Rhode Island was to have taken part in the fourth attempt against Canada; but the public mind was soon to be diverted from schemes of conquest to the more imminent necessity of defense against the great armada with which France threatened to retake Louisburg and conquer New England. The greatest alarm pervaded the colonies, and the assembly of Rhode Island, convened in extra session, ordered that a new battery be added to Fort George, a large garrison be provided, and an ample supply of ammunition be procured for the work.

Upon the news of the armistice between the belligerent powers, which preceded the conclusion of the peace of Aix-la-Chapelle in 1748, the garrison of Fort George was disbanded; but a few years later the work had again to be prepared for the renewal of hostilities between England and France on the question of the boundaries of their North American possessions.

The "Old French War" followed, during which Braddock was defeated, Fort William-Henry captured, Abercrombie repulsed at Ticonderoga, Fort Du Quesne taken, and Canada conquered. In this long struggle the colonies materially aided the mother country, besides providing for the defense of their Lake and Atlantic coasts. No point along the latter was more important than Narraganset Bay. Hence Fort George was fully repaired and almost rebuilt by liberal appropriations made by the assembly of Rhode Island. In 1761, this work was reported, with "twenty-six mounted guns," to be in excellent fighting order.

The peace of Paris, in 1763, thanks to the genius of Chatham and the valor of Wolfe, had transferred all of French North America to Great Britain; but this colossal contribution to the power of the latter was attended with consequences which were destined to wrench an empire from exulting Albion. In the nine years' contest, which had just terminated, the colonies had realized their military prowess, became acquainted with the customs of martial life, were taught to endure the hardships of the camp, had learned the stern lessons of self-sacrifice, became habituated to discipline and to confidence in themselves, and, though sometimes defeated and thrown to the ground, Antæan-like they rose renewed in their strength for new contests.

Only two years had elapsed after the peace of Paris before ungrateful Britain began that series of oppressions which culminated in American independence. Of that attractive history we must limit ourselves to narrating the heroic part taken by little Rhode Island on the shores of Narraganset Bay. The first act of its open resistance was a mèlée, July 9, 1764, between a boat's crew of the British schooner St. John attempting to carry off an alleged deserter from Newport, which was forcibly resisted, and led to the seizure by the town's people of Fort George, whose guns were trained upon the Admiral's ship—the *Squirrel*—against which eight shots were fired. The next year a mob of sailors took possession of and destroyed one of the boats of the English ship of war—*Maidstone*—engaged in impressing seamen in Newport harbor; then, in 1769, came the scuttling of the British armed sloop—*Liberty*—and the dragging of her boats in triumph through the streets of Newport; and, three years later, the *Gaspée* was captured and burned by armed Rhode Islanders in the upper part of Narraganset Bay. All of these daring acts took place long before the battle of Lexington opened, in 1775, the grand drama of the Americam Revolution.

Forseeing that the die must soon be cast, the assembly of Rhode Island, December 5, 1774, ordered the dismantling of Fort George to prevent its use by the enemy, and for safety removed to Providence its forty cannon and a large supply of ammunition. Batteries were erected also on Fox, Sassafras, Field, Kettle, and Bullock's Points, to defend Providence river; upon the west side and southern end of Popasquash Neck to guard the passage between it and Prudence Island; and upon the southern extremity of Warwick Neck to command the entrance to Greenwich Bay.

In quick succession, other places were so protected as to guard against the aggressions of British ships, whose crews were burning houses and barns, plundering the islands and shores, keeping the watch-worn inhabitants in constant alarm, and even threatening to destroy Newport. Such were these depredations that the Continental Congress was memorialized to protect Rhode Island with its one hundred and thirty miles of coast line and two navigable rivers exposed to the enemy.

Early in 1776, the Marine Committee of Congress, by active exertions and at great expense, had fitted out a squadron of eight vessels, mounting over one hundred guns, which sailed upon a cruise under Commodore Hopkins of Rhode Island. He had been very successful in making captures; and, being desirous of obtaining a supply of powder, then very scarce, he made a descent upon Nassau, New Providence, the capital of the Bahama Islands, captured its two forts with over an hundred cannon and a large amount of military stores, besides taking many prisoners of war, including the governor and lieutenant-governor. On his return, he encountered a British frigate of twenty guns, off Block Island, which escaped from him and ran into Newport harbor. This was the signal for the British fleet to go out in pursuit of the audacious Commodore. The night after, April 6, 1776, a slight battery was thrown up on Brenton's Point and armed with several pieces of heavy artillery, which compelled the frigate Hopkins had encountered to retreat further up the bay, but the next day she escaped to sea. Shortly after, the *Scarborough* of twenty, and *Cimetar* of eighteen guns, with two prizes, anchored in Newport harbor a little to the south of Rose Island. Two row-galleys from Providence recaptured these prizes, and, with the assistance of a battery, thrown up on North Point* (present site of Fort Greene), compelled the enemy's vessels to seek refuge under Conanicut Island. From this position they were driven by a battery erected at the Dumplings, and were obliged to put to sea, April 14, 1776, under a vigorous cannonade from Brenton's Point and Castle Hill, where a small earthwork had been hastily thrown up, the remains of which are still to be seen. Narraganset Bay was now free from all British cruisers, and on May 4, 1776, Rhode Island, by a solemn act of the General Assembly, declared her Independence of the mother country, two months preceding that by the Thirteen United Colonies.

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* From this Point a royal salute was fired, March 18, 1766, upon the repeal of the British Stamp Act.

Fig. 1.

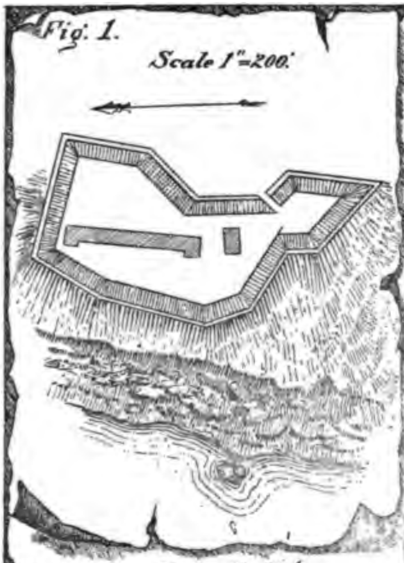
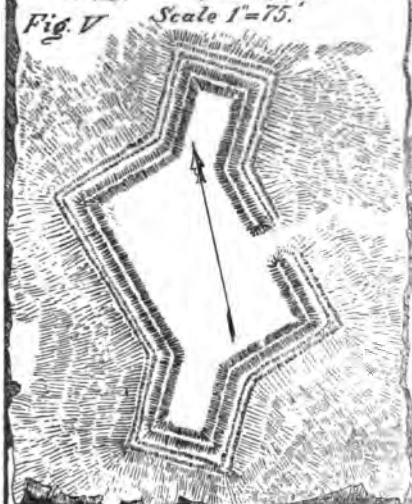


Fig. V



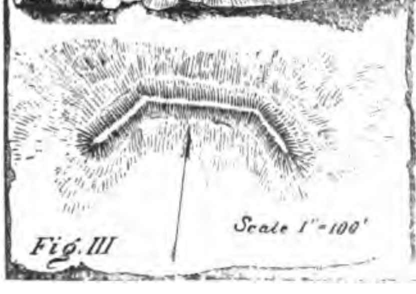


Fig. III

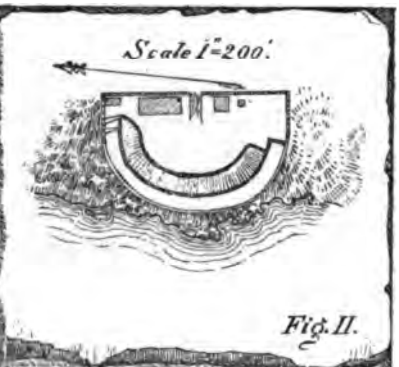


Fig. II.

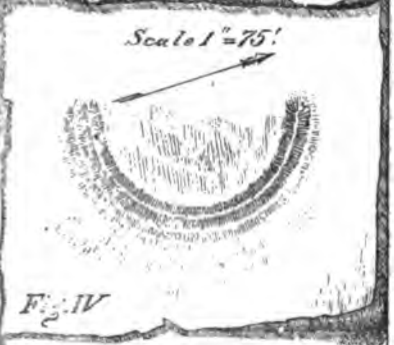


Fig. IV

I. AMERICAN BATTERY,
NORTH POINT,
Thrown up in 1776.

II. FORT GREEN,
NORTH POINT,
Built in 1798-1800.

III. FORT CHASTELLUX,
HALLIDON HILL,
Thrown up in 1780.

DEFENSES of the WEST PASSAGE,
1777-78.

IV. BATTERY ON THE BONNET.

V. BATTERY ON CONANICUT I.

Howland and Bristol ferries already had been fortified, and, to prevent further incursions through the main entrance to the Bay, old Fort George, now called Fort Liberty, was immediately reconstructed; a stronger earthwork was erected upon Brenton's Point; and the battery on North Point was enlarged and armed with thirteen of the guns captured at Nassau by Commodore Hopkins (see Plate I, Fig. 1). These defended Newport harbor and the middle entrance to the Bay; but the west passage was without fortifications.

The British Army, March 17, 1776, had been driven by Washington from Boston; or, as the Earl of Suffolk absurdly spoke of this inglorious retreat in the House of Lords: "General Howe thought proper *to shift his position* in order, in the first place *to protect Halifax*, and after that object was secured, *to penetrate by that way into the interior country.*"

It now became necessary for the fleet of England to possess some more secure and capacious roadstead. No place offered such great advantages as Narraganset Bay, where her ships could ride at anchor within its land-locked waters; and no safer base was to be found for the lodgement of her army than the sea-girt isle of Rhode Island. Once in possession of this natural fortress, Britain, with her army and navy, could menace every Atlantic port, and almost bid defiance to the United Colonies.

Accordingly, December 7, 1776, while Washington was in the Jerseys with most of the American army, Sir Peter Parker, with a British fleet of eleven vessels of war (seven line-of-battle ships and four frigates), convoying seventy transports having on board six thousand troops, passed unobstructed through the west passage into Narraganset Bay and rounded the north end of Conanicut. On the following day the British and Hessian troops, under command of Sir Henry Clinton, disembarked on Rhode Island and marched into Newport. Consternation spread on every side; the islanders fled, with their effects, to the main land; every defensible point on Narraganset Bay was occupied by American troops; and the entire State of Rhode Island became a vast camp confronting the enemy.

Brigadier-General Mulmedy, a French officer, reported at Providence, December 13, 1776, as Chief Engineer and Director of the American Forces, and was vested by the assembly with plenary powers "to erect such works and at such places as he shall think proper."

According to Blaskowitz's Chart of Narraganset Bay, made in 1777, the following American forts and batteries existed, viz:

	Guns.	Caliber.
Providence Fort.	50	18 and 24 p'ds.
Popasquash Battery	6	18 pounders.
Bristol Fort	8	18 pounders.
Batteries at either end of Bristol Ferry	3	18 pounders.
Howland Ferry Defenses	7	18 and 24 p'ds.
Fort Liberty, Goat Island, in Newport Harbor	25	18 and 24 p'ds.
North Point Battery (site of present Fort Greene) . .	20	18 and 24 p'ds.
Dumplings Rock Battery	8	18 pounders.

The armament of the American Batteries at Fox, Sassafras, Field, Kettle, Bullock and Warwick Points are not included in the above.

Upon the British occupation the works on Conanicut, Goat, and Rhode islands fell into their possession.

At the same time that the Americans were erecting defensive works, the British engineers were not idle. They soon began to throw up redoubts on the east side of Rhode Island near Fogland Ferry; on the left bank of Lawton's Valley; and on Butt's Hill near the north end of the island. In 1777 (see Plate II.), they intrenched Newport with a strong continuous line, which ran northerly along the crest of the height rising above the right bank of the inlet to Easton's Pond, then turned westerly towards Wonumetonomy (corrupted to Tomony) Hill, and continued north of this height to Coddington's Cove. Five advanced works protected the northern branch; some batteries, of later construction, covered the western branch; Wonumetonomy Hill was occupied by a strong redoubt; and a heavy battery was erected at Coddington's Cove.* To further strengthen this line, a thick abattis was placed outside of the fortifications, and the inlet to Easton's Pond was deepened by damming it at intervals. At Barker's Hill, near the Sakonnet or eastern passage, was a large redoubt, and near it a smaller one to guard the approach to the right of the British intrenchments, while minor earthworks occupied advantageous positions about the lines.

An attack from Tiverton upon the British works, by General Spencer with nine thousand American troops, was projected in October, 1777, but various untoward circumstances prevented its accomplishment.

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* The ruins of redoubts and batteries are still visible on Bliss' Hill, Van Rensselaer's Place, Governor Collins' former residence, Bailey's Farm, and Coddington's Cove, besides a more advanced work near the shore north of Coddington's Cove, which probably was thrown up in 1778.

Important events were transpiring elsewhere at this time. The battle of Germantown had been fought October 4, and on the 17, Burgoyne's army had surrendered at Saratoga. The spirit shown in the former notwithstanding the loss of Philadelphia, and the success of the latter, convinced the French court that the Americans were strong and in earnest. Hence the Treaty of Alliance, between France and the United States, was signed February 6, 1778; but it was not till July 29, following, that Count d'Estaing, with a fleet of twelve ships of the line and four frigates, appeared off Rhode Island and blockaded the entrances to Narraganset Bay. The next morning two of his ships ran up the west passage under the fire of a British semi-circular battery, near Bonnet Point on the Main (see Plate I, Fig. 4), and a rectangular flanked redoubt on the southern part of Conanicut Island, near Beaver Head (see Plate I, Fig. 5).* The daring of these French ships, supported by a large fleet in the offing, caused the British to abandon the Bonnet and the batteries on both shores of Conanicut Island; and burn, blow up, or sink the whole of their armed vessels (mounting 212 guns) in Narraganset waters. All was now alarm in the British camp; yet, from some unaccountable delay and want of concert between the French fleet and the American army, ten precious days elapsed without striking an effective blow upon the demoralized enemy.

It was not till August 8 that d'Estaing entered Newport harbor in force, when the British withdrew their outposts from the head of the island and concentrated their entire army within their Newport lines; and, not till the next day, were the four thousand French troops landed on Conanicut, and the advance, by Sullivan with his motley assemblage of ten thousand men, made from Tiverton and Fort Barton (on its heights) to occupy the abandoned British posts. The opportune moment for a telling attack upon the enemy unfortunately had now passed, for Lord Howe, with a British fleet of thirty-six sail, hove in sight, whereupon the French troops re-embarked, and the next morning d'Estaing put to sea to engage the English admiral. As we are not writing the history of the war, we must omit an account of the naval actions which followed; the injury done by the tempest to both fleets; and the causes of d'Estaing's failure to further co-operate with his American ally.

The French fleet sustained considerable damage, in entering and leaving Newport harbor, from the heavy cannonade kept up by the British batteries at and near Castle Hill, on Brenton's

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* The remains of both the Bonnet and Conanicut batteries are still visible.

Point, Goat Island, and North Point. All of the Conanicut l teries had been abandoned, their guns spiked, and their m zines destroyed, in anticipation of the occupation of that is by the French.

The American light troops, August 10, 1778, advanced to wi in a mile and a half of the British intrenchments; but, in co quence of the great storm, it was not till the 15th that the r body of Sullivan's army pushed forward and encamped with two miles of the enemy's works. That night a battery, seventeen pieces of heavy artillery, (see Plate II), was c menced on Honeyman's Hill to support our right flank and command the British defenses on Bliss' Hill. For five from the 16th to the 20th, our siege-works were pushed forwa with vigor and extended to the left, where batteries were lished to threaten the enemy's right. An incessant canno was kept up from four batteries to which, on the 23d, we add fifth. Such was the effect upon the enemy that the British, the 19th, began an inner line of intrenchmentss on a con curve extending from a strong redoubt near the north end of "Cliffs'" (Fearing's Place)* to the North Battery on the Besides the two strong works at the extremities of this line, th were three intermediate batteries and two detached redoub one within and one without this line—the former to sweep approach by Easton's Beach and the latter to command opening between the two lines of intrenchments.

Count d'Estaing returned to Newport on the 20th, w greatly encouraged the besiegers; but, on the next day, he sai for Boston to repair damages to his fleet.

Apprehending the approach of the British fleet with reinfor ments to the garrison of Newport, Sullivan abandoned his d of storming the English intrenchments, though all but o the enemy's outworks facing eastward, had been vacated. O the evening of the 28th, Sullivan raised the siege and ret to Butts' Hill, forming his line of battle supported by l te and intrenchments, across the head of the island (see Plate II). The so-called "Battle of Rhode Island," which took place the next day, will be passed over, as it forms no part of sketch, except to say that the works on Butts and Turkey Hi played a prominent part in that contest.

The British remained undisturbed on Rhode Island till October 11, 1779, when a fleet of fifty-two transports arrived from New York to carry away their troops and military stores, besides

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* Slight remains of this redoubt are still visible.

forty-six families of Tories. After destroying the lighthouse at Beaver-Tail and leveling the battery at North Point, the vessels, as fast as they were loaded with stores and ordnance were moored off Brenton's Point to receive the troops, who burned the barracks they had left. Before sunset of October 25, 1779, Rhode Island was relieved of its detested foe, which had left nothing behind but the utter desolation it had wrought during its occupation of nearly three years. The suffering of the inhabitants was extreme, particularly during fhe following winter, which was so cold that for six weeks Narraganset Bay was frozen over, and the ice extended seaward to Block Island and as far as the eye could reach.

The next year the murky cloud, which had so long hung over Narraganset Bay, was lifted, and the bright sunlight succeeded on the arrival, July 10, 1780, of Admiral de Ternay, with a fleet of forty-four armed vessels and transports bringing into Newport over five thousand French troops, commanded by Count de Rochambeau. The following day the army landed, and was put in possession of all the defenses of the harbor; and on the succeeding night the city was ablaze with a brilliant illumination in honor of its guests, among whom were some of the most distinguished noblemen of France. Soon British tyranny was forgotten, and "the wounds inflicted by Hessian ruffianism were healed by the balm of French politeness."

Washington, who came to Newport, March 6, 1781, to confer with Rochambeau about an active campaign, had a most notable reception by the citizens of Newport and the officers and troops of the French army. The splendid ball then given, and its gay assemblage of fair women and brave men, was a brilliant episode in the revolutionary annals of Rhode Island.

From various memoirs, particularly that ot the Count de Deux-Ponts, we learn most of the details of the operations of Rochambeau's army in Rhode Island. Soon after its arrival, the British fleet of twenty ships threatened to force a passage through the the main channel into Narraganset Bay. To guard this entrance, Rochambeau threw up batteries, armed with twelve pounders, on Brenton's Point, while the French navy occupied others on Conanicut Island; but these latter were abandoned, July 27, 1780, as they were accessible on all sides to British assaults. When the reports of Sir Henry Clinton's intention to attack the allied forces were confirmed by information received from General Washington, the French commander, with the aid of the Rhode Island militia, repaired and remodeled all the works thrown up by the British when they held Rhode Island; and added others, particularly redoubts on Coaster's Island, and a strong work on Rose Island* armed with forty pieces of heavy artillery. With such a powerful battery to defend the right of the line of seven heavily armed French ships, and the guns and mortars of Brenton's Point to protect its left, the whole presented a formidable array of land artillery and naval broadsides to guard the main entrance to the bay. Till the departure of Rochambeau, June 10, 1781, he, with the assistance of many officers of engineers, continued to strengthen all the batteries, particularly those on Goat Island which had not been destroyed upon the British evacuation. Among the new works thrown up by the French was a battery on Hallidon Hill (see Plate I, Fig. 3) as this height commanded, at short artillery range, all the batteries at Brenton's Point and on Goat Island. It was then called Fort Chastellux, after the Chevalier de Chastellux, one of Rochambeau's *Mareschaux de Camp.* After the Revolution it was known as Fort Harrison, being on the Harrison farm, and since, it has acquired the name of Fort Denham from some local association. What remains of it is situated in front of the "Thorp" cottage. Other batteries on the southern shore of Rhode Island were built during the Revolution, of which the remains of one are still visible on the "Ocean Drive," near the southwest extremity of the island, at Winans' cottage.

[TO BE CONCLUDED].

General GEORGE W. CULLUM,
Corps of Engineers, (Retired) U. S. Army.

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* This small island, called Conskuit by the Indians, was purchased, in 1675, by Peleg Sanford from the Sachem Mausup.

THE BICYCLE AND ITS ADAPTABILITY TO MILITARY PURPOSES.

(Continued from the September-October *Journal*, Vol. VI, No. 2.)

PART III. THE MILITARY USES OF THE BICYCLE.

Unless some radical and entirely unforseen improvement takes place, it would appear that the fire-arms of the present day have reached about the maximum state of efficiency in the small caliber bullet of the magazine and automatic machine guns, and in the shrapnel and shell of the quick-firing field piece. It would therefore seem that the most promising field for increasing the efficiency of troops now exists in the matter of improving their marching capabilities; and it is to this end that under suitable conditions the employment of the bicycle has been recommended.

We may state as a principle, that it is proper to make use of any means of transportation that will facilitate the necessary movement of troops between two points—either by increasing the rate of march, or by decreasing the amount of work performed in marching,—so long as such means do not tend to compromise the safety of the troops moved. This rule applies equally to a single soldier or to an army corps, and whether the method adopted be the railroad, the steamboat, horsed or horseless carriages, horseback, or the bicycle.

Let us apply this principle to the bicycle.

The following have been suggested as some of the possible uses of this machine in military transportation:

1. For orderly, messenger, and signal work.
2. For the "service of security and information."
3. For the rapid movement of large bodies of troops.

These were the first uses that the military bicycle was put to, and it is in these rôles that the advantageousness of its employment is most generally conceded. In garrison and in permanent camps there can be no longer any doubt as to the value of the bicycle messenger. The economy of time and work is too evident for denial.

In the field the employment of bicycle *estafettes* has been found valuable for the purpose of keeping up communication between the head and rear of marching columns, carrying despatches, preserving touch with troops marching on parallel roads, etc.

The extent to which their employment is permissible will be greatly dependent upon the character of the road. But in no case can the cyclist courier entirely displace the courier on horseback; each must be ready for use, and the one employed that seems best suited to the particular circumstances. On country roads, choked with troops or trains, and without side or foot paths, the cyclist would make comparatively slow progress and the horseman would probably be preferable. The same would also be true in carrying messages across country for short distances, as during the progress of an engagement. In very urgent cases the same despatch might well be entrusted to both horse and cycle messenger.

On the other hand where journeys of considerable length are to be undertaken, covering distances of from 12 to 20 miles or more, the bicyclist would generally have the advantage; and in longer distances he would gain proportionally. This is due to the fact that while the horse may be urged for short distances to a greater speed than the cyclist can make, and moreover is less embarrassed by obstacles met in the road, on the other hand the endurance of the cyclist far surpasses that of the horse, as does likewise the average speed which he can make in covering long distances.

The superiority of the cycle for courier work, where long distances are to be covered, is perhaps best shown in the races between the cities of Berlin and Vienna, arranged conjointly by the Emperors of Germany and Austria. An equal number of German and Austrian officers were specially picked, and mounted on the finest steeds to be obtained. The race tested to its utmost the endurance of both man and beast. 19 horses perished of fatigue on the way; as many more died shortly after the conclusion of the race; and all that were ridden were practically ruined. The winner made the distance in 72 hours, or almost exactly three days. The others were considerably longer, and very few completed the trip under four days.

In a wheel race instituted some time later, the same course was covered in 36 hours, or in half the time required for the winning cavalryman; and the wheelmen participating were by no means exhausted.

In my opinion cyclist couriers could be employed to great advantage within a permanent fortification.

Take for instance a seaboard fort, where the control of the various batteries—which may be separated by considerable distances,—is under the direction of the Commandant. Here good roads should be available, and all the conditions should be favorable for the employment of the bicycle. The Commandant, entrusting his orders (verbal or written) to the bicycle messenger, may depend upon their being accurately delivered in short order. Of course it is to be presumed that electrical communication will be maintained wherever important; but this may be overworked or break down entirely at a critical period. The telephone has not yet been proved altogether reliable, for military use, under service conditions; and in many instances the courier would be both quicker and more trustworthy than the telegraph in the delivery of a message.

Closely connected with the subject of military couriers is that of military signaling. We have already noticed two bicycles equipped for the use of the Signal Corps. One, a "Columbia" tandem, was provided with suitable flags, and carried a complete set of arms and equipments for its two riders. The other was equipped with an attachment for automatically unreeling and laying the cable of the field telegraph or telephone, and for rapidly taking up the same. In view of the progress that is being made in the use of a fine naked wire in field telephony (see *Journal U. S. Artillery*, Vol. II, p. 99; Report Chief Signal Officer, 1895, p. 6, etc.) it would seem that this application of the bicycle would be of the greatest importance in establishing telephonic communication between the outposts, headquarters, and the various units of an army in the field. Would not the motor cycle, similar to the one previously described (*Journal U. S. Artillery*, Vol. V, p. 247, et seq.) be of great value for this purpose, enabling a larger load to be carried, a heavier and stronger bicycle to be used, and the machine to be driven over roads impracticable for the common safety? Such a motor bicycle, it would appear, might well take the place of the "outpost cart" (see report Chief Signal Officer, 1895) in carrying capacity, while the fact that it is narrow and that its two wheels "track," would allow it to pass by trains, troops, and other obstructions in the road more readily than the "cart," and at the same time permit its use in narrow footpaths and trails where the latter could not be taken at all. The small amount of coal oil required (one gallon per 100 miles, or thereabouts) could be readily carried, or obtained almost anywhere in the country traversed.

The bicycle is as well adapted for carrying the heliograph, in countries where that instrument would be of value, and the flash lantern, as it is for carrying flags; and for all such light work seems to fulfill in many respects most admirably the needs of the signal department. It can, however, only be applied to convey light loads, and will never replace the regular field telegraph wagon and its equipment for establishing permanent and substantial military telegraph lines; while its use is still further limited to a country in which the communications, if not the best, are at least fairly good.

2. For "the service of security and information."

For this service cavalry has always been deemed in general best suited; and it is universally admitted that if modern fire arms have resulted in reducing the importance of cavalry on the actual battlefield, strategical and logistic considerations have tremendously increased its importance elsewhere, so that a large force of cavalry is to-day, for an army, a greater necessity than ever before. On the other hand the limited time afforded for preparation, in modern war, the immense armies now placed in the field, with the consequent enormous demand for draft animals for the artillery, trains and other purposes, make it more difficult than ever to equip and mount anything like an adequate proportional cavalry force; while the continual loss of horses due to various causes, and the necessity of providing for their subsistence, have still farther increased the difficulties inherent in the situation. Not only will the service of security and information demand all the cavalry that can be put in the field, but a much larger force than this will be called for, so that the cavalry will have to be supplemented by large numbers of other troops. But unmounted infantry lack the necessary mobility to co-operate with cavalry to advantage; to mount infantry is, as we have shown, for lack of animals out of the question; and its conveyance in special wagons designed for the purpose, as sometimes recommended, will be generally impracticable; but to mount infantry on bicycles seems to us to be, not only the one alternative left, but entirely feasible under ordinary conditions.

Indeed, military cyclists seem to be especially well adapted to this service. Operating well in advance of the main army, the roads will be unencumbered, nor will they as a rule be cut up by heavy transportation over them. The cyclists will therefore possess much greater mobility on this account. Moreover, the screen will ordinarily be subdivided into many component parts —detachments and patrols ranging from a single man up to a battalion—and this is just the condition for the most favorable use of cyclists as combatants, since it gives them more "elbow room," makes compactnes of movement of less importance, and therefore allows, within limits, more opening out and the changing of the rate of march to accomodate the varying condition of the road as to grade and surface. Such bodies of cyclists, manoeuvering habitually in advance of the cavalry portion of the screen, or even entirely independently of it, may maintain communication with each other by special couriers using lateral roads, and should offer a most effectual mask behind which the main body can be maneuvered in perfect security.

The principles governing their movement are the same as with other troops in this kind of work.

Groups of from 15 to 25 cyclists, it is safe to say, could defend themselves against any mounted cavalry likely to be encountered, and would have the advantage, in that the latter would offer the larger and better target. A stray bullet would be more likely to disable a horse than it would be to disable a bicycle. Good positions for cyclists would usually be found along the bank of a stream, guarding a bridge, or upon the summit of a hill or swell of ground. Here, if pushed back, the grade assists their retreat, while if successful it equally facilitates their advance in pursuit.

On the retreat the tactics of the bicyclists would seem to be similar: that is, to take up positions upon every swell for resistance, causing the advancing force to dismount and deploy, until, when the pressure becomes too great, they leap into the saddle and quickly disappear only to take up a similar position on the very next summit.

Colonel Saville, in an article in the *Journal of the Royal United Service Institution* (Vol. 32, p. 739) makes particular note of this circumstance in recounting the employment of the wheel in some of the English field maneuvers. The account is interesting, and we quote from it as follows:

"On the following day the cyclists were told off in two bodies to act against each other offensively and defensively along the road between Salisbury and Winchester. One body, representing a rear guard took up defensive positions where the ground offered favorable opportunities and awaited attack. It soon became apparent that a marked advantage rested with the defenders having cycles if opposed only by cyclists. Good defensive positions, generally at the top of a long slope and invariably with a downward slope close in rear, were selected by the rear-guard commander; the assailants reconnoitered these positions with their advanced scouts, who always avoided falling into ambushes, and when the main body came under fire, it dismounted, assumed the attack formation, and advanced. The defenders never allowed the attacking party to close, but retired to their machines as soon as the position became unsafe, mounted and were quickly out of sight. The same tactics were repeated at the next favorable spot. The assailants were never able to pursue quickly, for they had to go back over the ground they had skirmished across to fetch their machines, and then either ride slowly or push up the long slope again.

Attention will probably now be turned to means towards lessening the disadvantage I have mentioned. In the first place if the cyclists were co-operating with cavalry the difficulty would be almost entirely removed, for the cavalry would take up the retreat at once and the cyclists could easily come up in time to force without delay the next position taken up by the retreating party. Or, if some means were found of coupling bicycles together, some men could be left to push them on nearer to the fighting line at the conclusion of the action. Or, if the men are mounted on multicycles carrying ten or twelve riders, two men could push each unloaded machine forward. I have very little doubt that some remedy will soon be found, and in criticising the present weak points it is only fair to remember that military cycling is still now quite in its infancy and in the experimental stage."

The multi-cycle (previously illustrated and described),* the manufacture of which seems to have been inspired by this experience, has long been considered impracticable; but the reasons adduced by Colonel Saville do, however, seem to point out that the tandem is the proper military bicycle for troops constituting the advanced cavalry screen. Its employment would be somewhat as follows: as soon as the development of the enemy's fire makes it necessary to deploy and skirmish against his position, the troops dismount, leaving one cyclist with every two tandems, who corresponds exactly to a horse holder. And just as the horse-holder would advance with the horses after the enemy had been dislodged, so the "wheelholders" would bring up the cycles, riding one and leading the other. Thus the delay incident to the dismounted cyclists returning for their wheels, which Colonel Saville finds so objectionable, would have no place.

To execute this maneuver with single wheels, there would be available but 50% of the whole force for the fighting line—which would probably usually prove too small a number; but the tandem makes available 75% of the total—precisely the same as in the case of cavalry that are prepared to "fight on foot."

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* See "*Journal U. S. Artillery*," Vol. VI, No. 3.

The bicycle renders it possible for a small body of men, by making a long march, to surprise, seize and defend some strong point, such as a bridge, mountain pass or other defile, the possession of which may be invaluable. For this purpose the cyclist corps is peculiarly fitted. It may make with comparative ease several daily marches of 100 miles, if need be, and carry necessary provisions along with it. There are no clattering hoofs nor pillars of dust to give warning of its approach ; and no tired and sick horses to rest or secure forage for. In short, it combines all the requisites for a stealthy approach and complete surprise ; and furnishes a method by which reinforcements may be easily brought forward to support the force in advance. With a few pounds of gun cotton or other explosive, that could be readily carried, such a column directed against an enemy's line of communication could work in a few minutes the greatest damage by blowing up bridges, culverts, etc., and then make its escape almost before its presence had been detected.

Reconnaissance, military surveying, etc.—For this purpose, as is well known, the bicycle service offers great and special advantages. With the cyclometer, distances are measured far more accurately than is the case in ordinary route sketching ; and with the clinometer attachment, devised by Lieutenant Whitney of our service, the grade of the road is at once indicated. While the *mean grade* can be determined from any sketch containing contours, as located by the barometer, the *maximum grade* at any point is not as a rule thus indicated ; but this is an important matter, since it is here that the hard pull will come, stopping ensue, and the doubling up of teams be made necessary.

The most convenient method of plotting (one that I have tried with success) is to attach to the handle bar, with clamps, a small rectangular board, similar to the "cavalry sketching board," across which is stretched a continuous roll of engineer cross section paper, winding off from one spool and on to another, as required. With a supporting prop attached to the frame, which can be let down upon dismounting, the bicycle will remain erect, and serve in lieu of a tripod for our sketching board. The latter might with advantage be secured to the handle bar by a ball and socket joint admitting of its being easily levelled and oriented. Unfortunately it is not possible to read from a common compass attached directly to the sketching board, since the steel bicycle frame influences the needle. It is probable, how ever, that the needle might be compensated, as is done on shipboard; or by adopting the aluminium frame, already described, (see *Journal U. S. Artillery*, Vol. V. p. 240 *et seq.*) the difficulty would be entirely obviated, since the alloy used is non-magnetic.

The tandem would be very suitable for this kind of work. 1. One rider is entirely free, and can devote his closest attention to the country being sketched. 2. On dismounting he can go off to one side, and examine any of the ground not visible from the road, while his companion is filling in the sketch. 3. One man can keep the descriptive notes while the other is employed on the sketch; in all these ways the progress of the work may be greatly expedited; while their joint recollection would insure a more accurate sketch.

The value of a sketch, to illustrate in detail some important point, such as a bridge, ford, defile, range of hills for defensive position, etc., in connection with a field map, is now well recognized. But unfortunately this requires special talent. While anybody can be taught to make a route sketch with considerable facility and sufficient accuracy, the making of landscape sketches, free-hand drawing, etc., requires a special aptitude possessed only by a comparative few. Herein lies the great value of a camera. Anybody can be taught to use one with little trouble; to take a picture consumes but a fraction of a minute, instead of the long time required for a freehand sketch, and the result obtained is *absolutely accurate*, according to the laws of perspective, if a rectilinear lens is employed. Thus the field work is reduced to a minimum.

With the most improved cameras of the kodak type, the loading (or introduction of the sensitive film) is done in daylight, the film being protected from the action of the light by means of a strip of black paper, which is attached to the back of the film itself, and is wound up with it. This paper is numbered, corresponding to each exposure, so that it may be referred to conveniently by affixing its number to the corresponding place on the map or sketch. The development may be done at night, a simple bicycle lamp, with a shield of ruby glass, being all that is required in the way of a special outfit. The few chemicals required for developing, fixing, etc., are now put up in tablet form, weigh but a few ounces, and are very simple to use. A complete picture can be made, by the bromide process, in an emergency, in from 15 to 25 minutes from the undeveloped negative. We have space here only to thus briefly refer to this subject, but it certainly affords an important field in connection with military reconnaissance.

3. For the rapid movement of large bodies of troops.

While we fully believe that the bicycle will find its principle field for usefulness in the two services already discussed, there may be times when it can be used to advantage in moving a considerable body of men from one place to another, it being employed for much the same purpose as would be the railroad if it were convenient. The great objection to the use of the bicycle with a large force is the enormous lengthening out of the column which it entails, the consequent lack of mobility, and the confusion that is likely to result. We have seen that the average minimum distance permissible between cyclists is about 15 feet. Moreover, it is probable that on most roads where the cyclist would be thus employed, the habitual order of march would be the column of twos; very rarely would it be possible for four wheelmen to ride abreast, on the roads in the United States, at least; and frequently the column of twos would be reduced to that of a single file. Accepting then the column of twos with distances of 15 feet between machines, center to center, as our normal formation for order of marching, we have, *with single wheels*, a force of only 704 men to the mile: or with a tandem, a force of 1,408 to the mile; whereas, on a given mile a column of infantry (allowing one man for every half-yard) would number about 3,500 muskets; a column of cavalry would similarly count about 1,700 sabres. Thus it will be seen that, mounted on individual wheels, a column of cyclists, even under favorable conditions, will string out and occupy a stretch of road nearly five times as long as would be needed for the same body as infantry, pure and simple; and two and a half times as the length of the same body of cavalry; by employing the tandem, this disproportion is reduced by one-half, and it is probable that a considerable body of cyclists, on tandems, could be marched on good roads in but a little more space than that required for an equal column of cavalry accompanied by its train of forage and supplies. The great advantage which the tandem confers for the mobility of cyclists needs no better illustration than this.

Where the roads are favorable, we may expect to see the bicycle largely employed for bringing up troops from the rear, or transferring them from one theater of action to another. This will be particularly the case when these maneuvers are carried out well within one's own territory where the lengthening out referred to is immaterial. At the front, in the immediate vicinity of the enemy, the wheels would be left some distance behind, and might be loaded on cars or special wagons, to be taken elsewhere for use. We may expect to see a vigorous commanding general, hereafter, in marching through the country, gathering in all the bicycles for the use of his troops, as in former days, the horses were thus appropriated. An army corps of 30,000 men, thus mounted, would occupy without baggage a road space of nearly 40 miles, if mounted on single wheels, or of 20 miles if on tandems. Moving at the rate of 50 miles a day, its front would be about one day's march ahead of the rear of the column; or if the head of the column were put in march at 5 a. m., the rear, debouching from the same camp, could not start much before midday. During the march the smaller fractions should go into camp at about their respective places in column instead of closing up. It would be necessary for each man to carry sufficient rations on the wheel, since all of the trains of supply and baggage would be outstripped; and at the end of the movement he should find provisions at hand to draw from.

We will now illustrate the foregoing remarks by some account of the employment of the bicyclist in the armies of the two principal European military powers, during the field maneuvers of 1895.

Germany.

Up to within a year it cannot be said that the German military authorities looked with much favor upon the employment of the bicycle; but the service it rendered in the field maneuvers of 1895 were so marked that henceforth it will form a part of the regular equipment of the German army. The following account is that of a newspaper correspondent, and is translated, as quoted, from the *Allgemeine Militaer-Zeitung.*

"On all sides I began to fall in with the bicyclists of the II Corps. They wore caps and high canvas leggings for convenience in marching. The 'Letewka,'* open about the collar, secured free and easy respiration. Nothing is left of the knapsack but the "storming-bag," in which only that which is absolutely necessary is carried; from the waist belt hangs the ration bag and an orderly's case, which protects their maps. The saber is carried strapped to the steering pillar, or tied to the frame. No fire arm is carried but the pistol.

"The II Corps uses the cyclists only as orderlies for the staffs;

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* A light field blouse, with "turn down" collar.

they ride along with the supply train, and keep up contact between the troops and the train, but never, or only in utmost need, take part in battle. It is different, however, with the IX Corps, whose advance guard I came across early in the morning of September 9th. Upon inquiring whether they had yet secured touch with the II Corps, I was informed that already a detachment of two officers and sixty cyclists had fallen in with the outermost wing of the neighboring corps. Count Waldersee, the youngest of the Lieutenant-Generals, and commanding general of the IX Corps, is well known for the great interest he takes in bicycling applied to the military service ; and he utilizes it not only for the carrying of despatches, but for part of the fighting force as well.

"At Locknitz I met a still larger bicycle detachment. There was a bridge here across the Randow, and it constituted an important point, for the chief part of the IX Corps had to cross this to meet the enemy who were already in motion from Stettin towards the Randow. These cyclists were equipped like those of the II Corps in all essentials, except that they carried a rifle slung across the shoulders. This proved to be the successful section that early in the morning had made contact with their friends, the II Corps. A brisk young officer now unbuckled his saber, which was secured to the steering pillar as far down as the fork of the fore wheel. He rapidly fell out a detachment to accompany him, and made off south-east, at his commanding officer's orders, to determine whether they were opposed to the IX Corps of the guard, or to the III Corps. I joined this officer's bicycle patrol. After about half an hour's riding, we found ourselves in front of the enemy. The detachment dismounted in a twinkling, leaned their wheels against a tree, just as an advance party appeared. The lieutenant unstrapped his saber, gave the command, 'Battalion, load,' and in less than three minutes the adventurous squad were ready for fighting. After some firing the enemy retreated. Quick as lightning we were back in our saddles and off like the wind, over tilled fields and sandy roads, up hill and down dale with almost as much indifference to roads as cavalry.

"The detachment fulfilled its mission and in less than two hours the officer was able to report the information gained at headquarters. Meanwhile the remainder of the cyclists had made themselves comfortable in the village of Gocknitz, but not of course, without having established outposts.

"Throughout the continuance of the autumn maneuvers, I watched the bicycle soldiers in their various duties, everywhere respected and welcomed, and very much prized by the officers. Of course there is a limit to their mobility, but this country did not bring it out ; for everywhere we traversed it successfully ; through woods, over sandy tracts and tilled fields, and even across the swampy ground of the Randow fens. The enemy was never for a moment safe from this steel cavalry. They would appear as suddenly as a flash ; often by night a ghostly lamplight would come in sight, and before the sentinel could make out with what he had to deal, out would go the light, and darkness and the noiseless motion carried the cyclist unchallenged right past the hostile post."

FRANCE.

In the French autumn maneuvers of 1895, the bicycle was largely employed ; one section of 25 men was mounted upon the "folding bicycle,"* and attached as a support to a squadron of cavalry keeping contact with the enemy. The service it performed is well written up in the *Revue du Cercle Militaire*, under date of October 26th, 1895, from which we here give a few extracts.

"The enemy, beaten upon the left bank of the Oise, is retiring upon Roye by Teignie and Villequier-Aumont The brigade sets out in pursuit by the same route. The cavalry covers the front. The bicyclist section is still used as a support for the cavalry. Contact is made with the enemy's rear guard at Travecy. From point to point the cyclist section follows this rear guard with its fire. In such a pursuit cyclist infantry was shown to possess great advantages. Concealing itself behind a crest, wall or a farm house, it follows the enemy with its fire as long as possible ; then mounting, it hastens to take up another position and continues to fulfill its mission of harassing the enemy. Is it desirable to fall upon the enemy's flank? if so, a detour of a few miles is nothing for them ; with a few pedal strokes, they are brought into close proximity with the enemy's main body, in which they make a hole, and then quickly withdraw before their situation becomes hazardous.

"The cavalry officers who were present at the maneuvers with the cyclist section, whether working with it, or in the enemy's camp, unanimously recognize the damage that these swift foot-troops can inflict upon hostile cavalry, while at the same time it is of inestimable value to the cavalry to which they are attached."

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* For description see *Journal U. S. Artillery*, Vol. VI, No. 3.—Article by author.

In the United States our most probable field for the employment of bicyclists would appear to be during seasons of domestic trouble. as was the case in the "Debs Insurrection." Here it would seem that a well organized force of cyclists would be invaluable; for in the first place the roads and pavements in the city would be generally favorable for the best use of the wheel, allowing a column of fours to be used in the streets; and secondly the rapidity with which it can be moved would enable a relatively small force to cover and guard a great amount of territory. It is often objected that a man on a wheel is "helpless;" but this is true only in part; for a trained rider can make a vigorous use of one arm and still preserve perfect control of his machine. With the tandem, we would always have one rider that could be free to devote his undivided attention to a mob, and armed with a pistol and a saber, either of which in reach to be used at will, mounted cyclists might well be used offensively, and might prove almost as efficient in clearing a street as a squadron of cavalry, while possessing the advantage of greater speed and mobility. I do not intend by this to convey the impression that cyclists would attempt to ride down a mob—their proper course here would be to dismount and "fight on foot,"—but in passing through a street, well trained cyclists should be able to protect themselves and deliver telling blows against any bystanders who should attempt to interfere with their march. This would hold particularly with the tandem, for reasons already assigned. Cyclist sentinels would be far more efficient than those on foot. The experience of all the large cities in constituting a special cyclist police has been in every respect eminently satisfactory; and a sentinel thus mounted will take by surprise *in delicto*, and capture oftentimes the wrong doer, who would be warned by the noise of the approaching foot soldier or cavalryman, and escape.

So far as foreign wars are concerned, there is little likelihood of our having to contend aggressively with any European nation, while on the *defensive* we have little to fear, beyond the immediate vicinity of our seaboard. In a war against any of the American Republics we would probably find, from the undeveloped condition of the country and the poor roads, but little use for the bicycle. The one exception that we may note is the case of our being at war with Great Britian. In that contingency, a well organized bicycle force would be exceedingly valuable, in operating against Canada.

It is not in the province of this paper to enter into a general discussion of the strategical situation; but simply to note the facility with which a well organized bicycle column could act against that great artery of communication: the Canadian Pacific Railroad. From personal observation I am satisfied that the region to the west of Winnipeg offers special advantages for the employment of the wheel. For several hundred miles the country is almost a dead level, or only rolling, entirely unrestricted by fences, and the ground hard enough to make good wheeling feasible.

Good bicycle roads also exist in Maine, leading into the St. Lawrence River Basin and into the Maritine Provinces; and as we have already pointed out there are many avenues of approach open from the other New England states, Michigan and New York. Thus a body of cyclists concentrated almost anywhere along our northern frontier, is within a single day's wheeling march of the vital parts of the Canadian Dominion; with the great advantage offered that they can be always bold, without rashness, since there is, no matter in what direction they are forced to retire, a friendly frontier but a day's journey—or two days' at the most,—for them to fall back upon. Does any one doubt that their employment would meet with at least a fair amount of success?

Organization, Instruction, etc.

To obtain any kind of efficient service, our bicyclists should be organized into a Corps of Military Wheelmen, under an efficient head, and regulations drawn up for its governance. Such regulations, it would seem, would be the proper work of a board of officers who are familiar with the subject. The regulations should include the following heads (or something similar).

I. Organization.

II. Description of the machine.

1. The nomenclature and parts of the machine; fabrication and assemblement; etc.

2. The adjustment, care and preservation of the bicycle, including simple repairing, etc.

III. Dress, arms and equipments.

IV. Instruction and drills.

Organization.

As regards organization, it seems to me that the company of about 100 men (or an infantry company as now constituted), would make the best tactical unit; this to be subdivided into platoons, sections, squads, as in the case of the infantry company. While it is probable that the best results would eventually be obtained by giving the cyclists a regular corps formation, it would be undoubtedly wise, at first, as a provisional measure, to take men from the line and detail them for cyclist duty. A general order, issued from the War Department, would make this easy of accomplishment.

Such an order might provide that at every post where there are 50 or more bicycles owned and in use by the enlisted men, of foot organizations, the commanding officer be authorized or directed to organize a company or platoon of voluntary cyclists. The officers thereof should be charged with the instruction of the cyclists, in marching maneuvers, etc., and at the end of two or three months, should report to Army Headquarters, in writing, what they have accomplished; and give such recommendations upon the subject as their experience would indicate. These reports should be placed before a properly constituted board, empowered to draw up rules and regulations for a bicycle corps, select a model military wheel, etc.

Employment of Bicyclists in time of Peace.

It should be made the duty of military bicyclists to prepare maps and obtain information pertaining to all the more important parts of the country. A suitable organization should be able in the course of a few years to prepare accurate maps giving full details of all the main roads of communication in the States, and all the avenues of approach to the Canadian frontier. The road books published by the L. A. W. (League of American Wheelmen), have done a great deal in the way of giving information of our country roads in certain of the more populous states; these would be of great assistance in the duty devolving upon the bicycle corps; but they are not full enough of detail, and the maps are not drawn to a sufficiently large scale to make them suited for the military service.

We can conclude this article in no more appropriate language than the following, which I take from a recent number of the *Revue Militaire de l'Etranger.*

"Without sharing the enthusiasm of those who fancy they see the transformation of the cavalry into a bicycle corps, it is undeniable that the experiments undertaken in the course of the last maneuvers have singularly enlarged the field of usefulness for which the military bicycle has hitherto been regarded as suitable.

"The terrain will always remain an often time insurmountable obstacle for the machines, which would speedily become unfit for service if they were frequently used outside of the roads.

"But the service of reconnaissance and the rapid transmission of intelligence have had with modern armies such an enormous expansion that they constitute a tremendous drain upon the cavalry, and make it imperative to gather together every possible means to assist it in these duties and render it as strong as possible for combat.

"This rôle, it would seem, can be advantageously filled by detachments of bicyclists, vigorously and skillfully led. Such elements placed at the disposition of the independent cavalry divisions, by increasing their mobility, their security and their effective strength, would indisputably permit results to be obtained the importance of which are beyond denial.

"Thrown out in the advance of the infantry columns on the march, and patrolling far ahead, by day and by night, when the troops are at rest, they would effectively aid, and in case of need might entirely replace, the divisional cavalry, which would thus be free for other employment.

"But such missions cannot be entrusted to groups of cyclists gathered together by chance, without cohesion or special instruction. Physical and mental qualities, as well as previous knowledge of the machine, are elements that must be thought of in recruiting for this service; but it is only through a special course, directed according to a rational and progressive scheme, that we may hope to perfect these qualities, and instill into our military cyclists the necessary knowledge and cohesion to make them fit for the active part that they will undoubtedly be called upon to play in future wars."

WM. C. DAVIS,
2d Lieutenant, 5th Artillery.

PROFESSIONAL NOTES.

ORGANIZATION.

Referring to the account given in the January-February and the March-April issues of this *Journal* of "An experiment with Militia in Heavy Artillery work," it is to be noted that the following act of the legislature of Massachussetts became a law on May 12, 1897; this is the first step towards creating a Coast Artillery Reserve force.

Commonwealth of Massachusetts. In the Year One Thousand Eight Hundred and Ninety-seven. An Act to authorize the change of one or more regiments of Infantry to Heavy Artillery.

Be it enacted by the Senate and House of Representatives in General Court assembled, and by the authority of the same, as follows:

Section twenty-three of chapter three hundred and sixty-seven of the acts of the year eighteen hundred and ninety-three is hereby amended by striking out all of said section after the word "governor" in the sixth line and inserting in place thereof the words "may be changed to heavy artillery and uniformed and instructed as such," so as to read as follows:—

***Section* 23. The commander-in-chief shall arrange the infantry, artillery and cavalry into regiments, battalions and, when necessary, unattached companies, and not more than two brigades. There shall not be more than six** regiments of infantry, one regiment or more of which, at the discretion of the governor may be changed to heavy artillery and uniformed and instructed as such.

The immediate effect of the act will be to change the First Regiment of Infantry into a heavy artillery regiment, and, in course of time, it may be expected that the defences of Boston Harbor will have back of them an ample force of trained artillerymen to reinforce the regular garrisons.

The First Regiment, anticipating this action of the legislature has continued its heavy artillery work through the winter and will encamp at Fort Warren again for a week's practical instruction in August. Officers and men of the regiment are much pleased with the change to heavy artillery, and with the feeling, now given, that it is a permanent duty, take up the study and practice of its details with renewed enthusiasm.

It is to be hoped this example may be followed in other seaboard states.

1st Lieutenant E. M. Weaver,
2d Artillery.

TACTICS.

Artillery in the Greco-Turkish War.

Whatever opinion we may be disposed to entertain in regard to the importance of the question which has brought the rival forces of the Turks and Greeks into conflict with one another, or whatever may be our respective sympathies, whether with the aspirations of the representatives of the ancient Hellenic race, or with the followers of that prophet whose memory Carlyle delighthed so much to honor, it cannot be denied that, deplorable as these apparently unnecessary wars are, they serve a useful purpose to the lookers-on. Bye-elections are said to be the pulse through which the current of political feeling is indicated; so these miserable little actions, such as that of Yalu, between Japan and China, or the recent events at Mati and in the Malouna Pass, are invaluable as exponents of the relative importance attaching to the various fighting factors of armies and navies in their modernized condition. The lessons taught by the battle of Yalu have long outlived the interest taken in that action; and a careful observer of the development of ideas in recent battleships and cruisers knows how many of the changes made have been the result of experience gained during that sharp but decisive affair. Similarly, although it cannot be otherwise than a matter for sincere regret that a needless war has been entered upon, blood recklessly spilt, and thousands of homes needlessly ruined, we cannot be blamed for taking advantage of the opportunity and for considering the outcome of the whole in so far as it casts a somewhat lurid light upon our own military position.

Several points cannot fail to attract observation. For the past ten years Turkey has paid great attention to the arming of her field artillery. Herr Krupp has had a most active business agent in Constantinople, and not a day passed when the carriage of this agent was not to be seen beneath the portico of the offices of the Minister of War at Stamboul, as often as not without horses attached, for it is the custom of these contractors' agents to put their horses up, and take things very quietly when business is brisk. They never hurry themselves. The result was that a large proportion of the Turkish field artillery was armed with the very latest pattern of Herr Krupp's most powerful field guns, which were infinitely superior in flatness of trajectory and in range to those of the Greek batteries. Moreover, a number of small field howitzers were, we understand, included in their equipment, which made awful havoc of the retiring Hellenic forces as they were massed in the plains. *Apropos* of this point, it is interesting to note that our militrry authorities are at last arousing themselves to the importance of arming some of our batteries of artillery with the new 5½ inch rifled field howitzer. An experimental battery was supplied with this very useful weapon more than a year ago; and we understand that the result of practice made with it during experimental trials has been most satisfactory. The shell is of large size, weighing over 60 lbs., and the damage done with such a projectile in earthworks is of course considerable. Two other batteries are now to be equipped with 5½ inch howitzers, and probably others will follow. But these are a mere tithe of what will be required for the exigencies of active service. We seem to be always in the experimental stage. Here is a weapon which is of the most vital importance, as being the only one which can search out effectively the enemy's ordinary field batteries if well placed and screened in any way, which has taken six or seven years to evolve, and yet the batteries armed with it may be counted upon the fingers of one hand. Surely the terrific effect which the superior artillery arm of the Turkish forces has apparently had upon the Greek batteries ought to be a sufficient warning for our supine authorities? We are always quoting the volunteers as filling up the measure of our requirements. What, in the name of common sense, would have been the use of 227,000 volunteers in the Malouna Pass, with batteries of 8.4 centimeter field guns, and 12-cm. howitzers playing upon them from the surrounding peaks, at a range of three miles? Of course, we know there are volunteer artillery batteries. But, armed with muzzle-loading 16-pounders, which their untrained horses can scarcely drag into action, we should say that they would be more of an encumbrance to an army than a support. We would, therefore, urge upon the Director-General of Artillery the necessity for laying before the Superior Army Board, at the very first opportunity, our requirements in the shape of field artillery, our establishment at the present moment of this invaluable arm being microscopic. At least twenty batteries of 5½ howitzers should be organized, these being in addition to the ordinary strength of the arm in field guns as necessary for divisions and brigades.

Another point that we cannot help adverting to is the tendency of the current of events in Greece to upset, in a measure, the very strong opinions which have been expressed within the past few years upon the exclusive importance of "the command of the sea." During the war now under consideration the Greeks have had absolute sovereignty in this respect, whilst the Turkish ships, though goaded into the Dardanelles by the order of an unscrupulous master who cares not whether his battleships sink or swim, have remained quaking with terror behind the 35 cm. batteries at Chanak, refusing to proceed beyond the mouth of the straits. Nevertheless, the absolute sovereignty at sea possessed by the Greeks has been impotent to help them, owing to the paucity of their land forces. It must not be forgotten, however, that the command of the sea is a phrase of very wide meaning. For an insular people with enormous colonial possessions, sea command assumes a position which has nothing in common with a possibility of raiding an enemy's line, or interrupting his communications. That the Greek fleet has effected nothing of importance teaches no lesson of the smallest value to Great Britain.

—*The Engineer*, April 30, 1896.

ARTILLERY MATERIAL.

a. Guns and Carriages.

The Gledhill Built up Gun.

A new form of built up gun has been designed by Manassah Gledhill of Sir Joseph Whitworth & Co., Limited, of Openshaw, England. The following description is taken from the letters patent recently issued. The design has for its chief object the construction of a gun by building up a series of tubes, hoops or rings so formed, fitted together and united as to insure great strength and durability of the gun while permitting the ready withdrawal or removal of the liner and the insertion of a new liner without injury to or displacement of the other tubes or hoops.

The tubes A, B and hoop C of the gun are respectively indicated by these letters. *a* is the liner or inner lining of the gun. One important feature of the invention is the employment of peculiarly constructed locking rings *b b'* between the tubes A B and hoop C at the breech end of the gun, as follows: At the breech end of the gun, between the tubes A and B and between the tube B and hoop C, there is formed a cavity or recess the walls of which will be the surfaces of the tubes, as shown in Figs. 1, 2 and 3. On each of these surfaces is cut a screw thread, and into the cavity thus formed is inserted one of the locking rings, which is screw threaded on its inner and outer surfaces, as shown in Fig. 5 or in Fig. 6, to fit the threads in the cavity or recess, into which the ring is tightly screwed. In some instances there are formed segmental or interrupted screw threads on the ring and on the surfaces of the

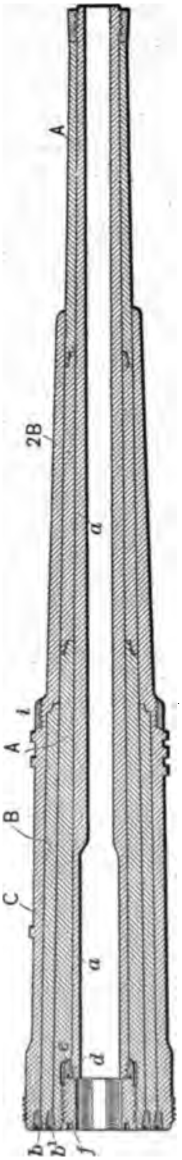

Fig. 1.

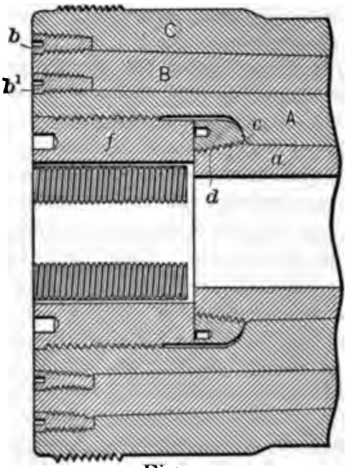

Fig. 2.

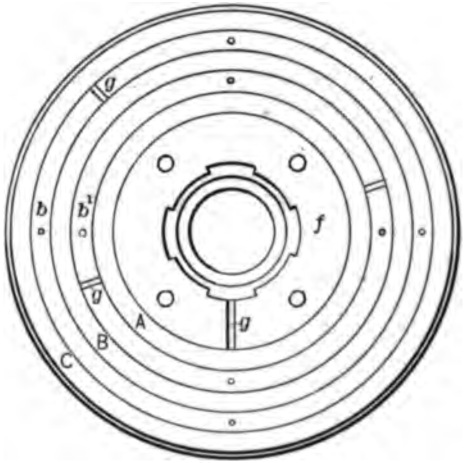

Fig. 3.

tubes or hoops in the recess or cavity, these segmental threads being so arranged that those on the ring will pass endwise between those in the recess, so that the ring may be freely inserted and then turned far enough round to cause the threads thereon to engage with those of the recess. By these means the tubes or hoops are secured firmly and solidly together at the breech end of the gun.

The tubes or hoops of which the gun is composed are preferably made in one piece and are continuously and uniformly tapered throughout their length, so that the required diminution in the external diameter of the gun from the breech to the muzzle is obtained without shoulders or sudden changes of thickness, which are very prejudicial to the strength of the tubes. The continuous taper of the liner *a* greatly facilitates its removal and replacement. Moreover, by the employment of the continuously and uniformly tapered tubes a method of manufacture can be adopted which avoids the necessity for the use of gauges in fitting the various tubes one upon another—that is to say, the builder can turn or otherwise form the outside of one tube and bore out the other tube so that both tubes are continuously tapered at the same angle from end to end and the external diameter of the one is so nearly the same as the internal diameter of the other that the outer tube can be placed very nearly in its ultimate position upon the inner tube without any or with but very slight pressure; then, the remaining distance and the angle being known, it is easy to ascertain the exact pressure to which the tubes will be subjected in forcing the one to its ultimate position upon the other. The liner *a* may be forced home by applying to it hydraulic or other pressure as great in amount as or greater than the total pressure exerted by the powder gases in the chamber of the gun. The tubes A B and hoop C may be put together by hydraulic pressure or with shrinkage.

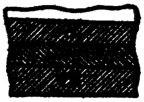
Fig. 4.

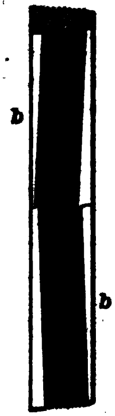

Fig. 5.

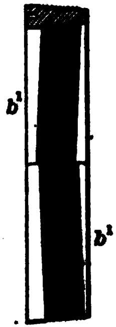

Fig. 6.

If the outer tube is to be shrunk upon the inner tube the builder can ascertain the exact amount to allow for shrinkage. Moreover, the continuously taper formation of the tubes greatly facilitates the uniform shrinking of one upon the other, a much lower temperature being required and the danger of injuring the tubes or hoops being much less than in the case of parallel tubes. The latter, unless the contraction of the outer tube is exactly equal or uniform at all parts, will be liable to have one end or part bind or become tight, while the other part or parts, still being free, as the tube continues to shrink will be drawn against very great frictional resistance toward the fixed end or part, thereby injuriously straining the metal; but with taper tubes this difficulty will not exist or will be considerably diminished. When the tubes or hoops are to be put together with shrinkage, it is preferred that they should be heated to a temperature not exceeding 300 degrees Fahrenheit. To facilitate the formation of the taper tubes and the accurate fitting of the one upon the other as above described, there is employed a mandrel which, in respect of its diameter and taper formation, is a counterpart or *fac simile* of the inner one of the aforesaid tubes. The outer tube is so fitted to this mandrel that when removed therefrom and placed upon the inner tube it can be placed thereon with very little pressure within a short distance of its ultimate position, and can then be forced home with or without shrinkage, as above described. This method of at first accurately fitting the taper tubes to each other within a short distance of their proper relative positions and then forcing one tube home or expanding and shrinking it upon the other secures the liner in the gun in such a manner that, although it will not be liable to accidental displacement, it can be readily withdrawn when worn without injury to or displacement of the other tubes or hoops of which the gun is built up.

As an alternative to the use of a tube made in one piece continuously taper from end to end, the builder, in some instances, makes the inner tube—that is to say, the A tube, containing the liner, or the B tube, or other intermediate tube or tubes—in two or more continuously taper pieces or lengths, united by screwing the pieces together, the screw joints being made taper, with a plain or unscrewed portion at the end of each hoop to insure the proper fitting of the parts together, as shown in Fig. 1 or Fig. 4. It is obvious that this form of joint, for the purpose specified, is stronger and more reliable than an ordinary rabbeted or square shouldered joint, and it considerably facititates the connection and disconnection of the parts.

Sometimes wire is coiled around the liner *a*, so that when the liner is in its place there will be a space between it and the A tubes surrounding it occupied by this wire, which will afford a strong and elastic support to the liner, so that it can withstand the stresses due to the firing of the gun without being so tightly forced into the A tube as to make its withdrawal therefrom a very difficult operation. On the breech end of the liner is cut a screw thread, whereon is fitted a nut *d*. In the gun shown in Figs. 1, 2 and 3 there is formed for the reception of this nut a recess or cavity in the end of the A tube, as shown at *c* in Figs. 1 and 2. Instead of the nut there is sometimes formed on the liner a solid collar, which will enter the recess or cavity. The nut *d* can be screwed upon the liner before the latter is forced home in the A tube, and affords the means for insuring or assisting to insure the accurate adjustment of the liner to its exact position within the tube and prevents injury to the latter by forcing the liner too far into the tube—that is to say, the nut *d* or the solid collar, being in close contact with the bottom or end of the recess or cavity in the A tube, will limit the endwise movement or adjustment of the liner, so that in applying the pressure for forcing the liner into the tube no other precaution in respect of insuring its true position therein or preventing injury to the A tube will be necessary except to ascertain that the nut or collar is properly home against the end of the recess in the tube. Moreover, all danger arising from too great contraction of the tube in shrinking it upon the liner is avoided. The nut *d*, moreover, protects the screw thread at the rear end of the liner and can be readily unscrewed to permit the application of a device for removing the said liner.

The A tube at its rear end has provision for the reception of the breech plug ring *f*, which is screwed into the end of the tube and is so arranged that its inner end bears upon the rear face of the liner *a* and liner nut *d*. The breech plug ring has the usual segmental or interrupted screw threads to engage with similar threads on the breech plug. Sometimes the breech plug ring is split on one side, and one or more wedges or keys, *g*, are driven into the aperture, as shown in Fig. 3, to tighten the ring in its place. By this device the removal of the ring is made easy—that is to say, instead of having to exert sufficient force to unscrew the ring while its screw threads are tightly engaged with those of the tube, the builder can draw out the wedge or key, *g*, and thereby slacken the ring *f* within the A tube, so that the ring can be very easily unscrewed. Suitable means are provided for securing the wedge or key in place and for turning the ring in screwing it into or out of the tube.

The breech plug is usually cylindrical, but sometimes made taper, either with segmental or continuous screw threads, to facilitate the opening and closing of the breech. In some instances a hoop screw threaded internally is used, as shown at *i* Fig. 1, for securing together the adjacent ends of the hoop C and tube or hoop 2B, or of other tubes or hoops.

One important advantage arising from this construction is that the builder can make the parts interchangeable, so that if any part of a gun is injured or destroyed it can be readily replaced or renewed. Moreover, the invention affords the means for so constructing the gun that its various parts can be properly fitted together and then taken asunder and very conveniently packed for transport to any distant station, where they can with very simple appliances be again put together.

—*The Iron Age*, October 15, 1896.

b. Armor and Projectiles.

Tests of Armor Plates in the Witkowitz Iron Works.

On the 16th and 18th of September, 1896, in presence of a comission sent by the Imperial War Ministry (navy section) to Witkowitz, armor tests were carried on in the works there.

The object of the tests of the plates furnished by the Witkowitz works was a double one. In the first place, it was to be shown what progress the Witkowitz works had made in the preparation of ships' armor since the international tests conducted in Pola in November, 1893; and, in addition, a comparative test was to be made between a Harveyized special plate and an un-Harveyized homogeneous nickel-steel plate, the results of which are to serve as a guide in determining the Navy Department as to the armoring of a new ship.

It was assumed from the start that it would be possible to reduce the thickness of the plates, which had been fixed at 270 mm. as a maximum for the three coast-defense vessels *Monarch*, *Wien* and *Budapest*, then in course of construction, to 220 m. with the same strength of armor.

The plates 6402 and 6559 were tested with the Krupp 15 cm. gun, L/40, using steel armor-piercing projectiles, *Provenienz Streiteben*, which, judging by the appearance of the fragments were very hard and of excellent quality. The distance from the muzzle of the gun to the target was 59.8 m. All the shots were fired normal to the target.

The plate was held fast in a strong framework without bolts, on an oak backing 500 mm. thick, the wooden backing carrying in the usual manner two inner skins of sheet steel 12 mm. thick. The velocity of the projectile was measured at each shot, and the weight of the charge was accurately verified.

PLATE 6402.

The experimental special Harveyed plate, prepared by a process peculiar to the works, had the following dimensions: 1850 mm. long, 1475 mm. broad and 220 mm. thick.

Shot 1.—15 cm. steel shell L/3.2; weight 45.6 kg.

Velocity of impact	602.3	m.
Energy, total	844.16	mt.
Energy per cm. of circumference	18.033	mt.
Energy per cm.^{2} of cross-section	4.841	mt.

The projectile was shattered into fragments, of which 49, weighing 30.5 kg. in all, were collected.

The plate received an indentation 92 mm. deep; over an area 270 x 285 mm. around the point of impact, on the face of the plate, the hard layer peeled off to a depth of 10 mm. The back of the plate remained unaltered and showed neither bulge nor crack.

Shot 2.—15 cm. steel shell L/3.2; weight 45.7 kg.

Velocity of impact	693.4	m.
Energy, total	952.24	mt.
Energy per cm. of circumference	20.342	mt.
Energy per cm.^{2} of cross-section	5.461	mt.

The projectile was shattered into fragments, of which 41, weighing 21.5 kg. in all, were collected.

The head of the projectile remained sticking in the plate and fell out at the third shot; the depth of penetration could then be measured and was found to be 100 mm. The material over an area 220 x 190 mm. peeled off to a depth of 10 mm. On the back appeared a bulge 46 mm. high, free from cracks. The plate showed neither crack nor flaw on face or back; the backing remained unimpaired.

Shot 3.—15 cm. steel shell, L/3.2; weight 45.5 kg.

Velocity of impact	673.15	m.
Energy, total	1050.83	mt.
Energy per cm. of circumference	22.448	mt.
Energy per cm.^{2} of cross-section	6.026	mt.

The projectile was shattered into fragments, of which 48, weighing 18 kg., were collected.

The point of the projectile remained sticking in the hole made by the shot, its measureable penetration 52 mm.; the border of the point of impact over an area 280 x 260 peeled off as in previous cases. On the back of the plate appeared a bulge 41 mm. high, free from cracks; the plate shows no other defects whatever, either on its face or back.

PLATE 6559.

The un-Harveyed homogeneous nickel-steel plate, prepared according to a process peculiar to the works, had the dimensions 1720 x 1720 x 220 mm.

Shot 1.—15 cm. steel shell L/3.2; weight 45.5 kg.

Velocity of impact	608.4	m.
Energy, total	858.36	mt.
Energy per cm. of circumference	18.337	mt.
Energy per cm^2. of cross-section	4.923	mt.

The projectile was shattered into fragments, of which 25, weighing 32.5 kg. were collected.

The point of the projectile remained sticking in the plate but fell out at the second shot, leaving the depth of penetration measureable at 125 mm. Around the point of impact, over an area of 240 x 270 mm, the material was pressed away, without causing any portion of the face of the plate to peel off.

On the back there was no bulge, nor any cracks or other defects of any kind on face or back.

Shot 2.—15 cm. steel shell L/3.2; weight 45.7 kg.

Velocity of impact	638.9	m.
Energy, total	950.78	mt.
Energy per cm. of circumference	20.311	mt.
Energy per cm². of cross-section	5.453	mt.

The projectile was shattered into fragments, of which 28, weighing 27.5 kg. were collected.

The point of the projectile remained sticking in the plate, but fell out at the next shot, upon which the depth of penetration became measurable and was found to be 135 mm. Around the point of impact no edgings and no peeling off of the material visible. Neither cracks nor other defects visible on face or back. On the back no bulge.

Shot 3.—15 cm. steel shell L/3.2; weight 45.5 kg.

Velocity of impact	677.3	m.
Energy, total	1065.0	mt.
Energy per cm. of circumference	22.751	mt.
Energy per cm². of cross-section	6.108	mt.

The projectile was shattered into fragments, of which 24, weighing in all 24 kg., were collected.

The point of the projectile remained sticking in the plate; the depth of penetration became measurable at the next shot and was found to be 110 mm. Around the shothole on the face no edgings appeared, but the material flaked off as far as shothole 2. From shothole 2 a horizontal and a vertical through crack extended to the right and bottom edges, respectively. On the back no bulge was noticeable. The plate remained in its original position, and the wooden backing was not injured.

In this third shot it happened that, on account of the darkness, instead of having a distance of 4 calibers = 600 mm. mean distance between shotholes 2 and 3, unfortunately this mean distance was accidentally reduced to but 290 mm. This alone will explain the cracking of the plate, which would undoubtedly have resisted the attack, as may be concluded with certainty from the conduct of the plate at shot 4.

After the 3d shot, which was already fired with the maximum charge of the powder on hand, no further increase of charge—with corresponding increase of velocity—was possible; consequently, shot 4 had to be fired with the same charge as shot 3.

Shot 4.—15 cm. steel shell L/3.2; weight 45.55 kg.

Velocity of impact	677.3	m.
Energy, total	1065.0	mt.
Energy, per cm of circumference	22.751	mt.
Energy, per cm². of cross-section	6.108	mt.

The projectile was shattered into fragments, of which 51, weighing 22 kg., were collected.

Around the shothole there was neither edging nor peeling off visible. The depth of penetration of the projectile was 135 mm. A through crack, extending from shothole 2 through shothole 3 to shothole 4 resulted, and also another, not connected wilh the first, to the left-hand edge of the plate; besides, a hair crack running towards the upper edge of the plate made its appearance. From the slight depth of penetration of 110 and 135 mm., in shots 3 and 4, respectively, we may conclude that this plate would have easily resisted 15 cm. steel shells with impact velocities of 690 and 700 m.

Although the plate showed several cracks after the last two shots, it still held together, and the backing remained uninjured.

The result of the trial may be summed up to the effect that both plates, in spite of the reduced thickness (by 50 mm.), showed themselves far superior to the Witkowitz standard plate previously tested in Pola, and which was victorious over the products of all the different German and English armor-plate works.

Both plates showed that they possessed considerably more resisting power than was required to fulfill the conditions fixed for the three coast-defense vessels by the Navy Department of the Imperial War Ministry. The Witkowitz works guaranteed that the trial plates, tested under the conditions in force at Pola in November, 1893, would show such a behavior that no opening at the back of the plates would take place.

Comparing the two plates one with the other we are struck with the fact that the special plate, although Harveyized on the surface, was bulged out on the back, but still without in the least opening up, while the homogeneous plate showed no change whatever on the back.

In the following table the attempt is made to make a comparison between the tests above given and the recently officially published Krupp and American trials.

There is considerable difficulty in this attempt because in the trials to be compared the thickness of plates as well as the weights and velocities of the projectiles were different.

The formula which served as a basis for the comparison is that of De Marre, which expresses the velocity of the projectile as a function of the quality number for steel plates (1530), the diameter of the projectile, the thickness of the plate and the weight of the projectile:

$$v = 1530 \frac{d^{0.75}}{p^{0.5}} b^{0.7},$$

in which, v = velocity, d = diameter of projectile, p = weight of projectile, b = thickness of plate.

In the case before us the quality is to be regarded as the variable, from which the following table results:

Type of Plate.	No. of Plate.	Date of Trial.	Thickness of Plate. mm.	Projectile. Caliber cm.	Projectile. Weight kg.	Velocity attained m.	Quality Number.	Remarks.
Witkowitz.	6402	Sept. 16 & 17, 1896.	220	15	45.5	673.15	1929.3	
	6559	"	220	15	45.5	677.3	1941.2	
Krupp.	425 B.	Dec. 15-17, 1894.	146	15	51	475.7	1923.1	Bulged and cracked
	425 B.	"	146	21	95	476.0	2040.06	
	413 II.	"	146	21	95	437.2	1874.3	
Iowa.		Sept., 1895.	356	25.4	226.8	449.0	1381.9	
						567.0	1745.0	

From this table it appears that in quality the plates tested in Witkowitz proved far superior to the Iowa plate, and that, according to the official record, they are equal to the 146 mm. Krupp plate.

It should be noticed that the 220 mm. Witkowitz plates were not bolted, and had a weaker backing with thinner inner skins than the 146 mm. Krupp plate.

By calculation the thickness of a steel plate to resist a 15-cm. projectile with 677.3 m. velocity should be 309 mm., corresponding to a wrought-iron plate of equal resistance 443.5 mm. thick.

According to English authorities Harvey plates of the best quality surpass wrought-iron plates of equal thickness by 83%. The Witkowitz plates will surpass them by 101.6%.

—*Mittheilungen aus dem Gebiete des Seewesens*, No. II, 1897.

[Translated by J. P. W.]

Trial of Side and Deck Armor for the United States Battleships Kearsarge and Kentucky.

A test plate was recently fired at with a ten-inch gun at the Naval Proving Ground, Indian Head. The plate was one of a set of face hardened, reforged nickel steel plates, which is being furnished by the Carnegie Steel Company for the side armor of the *Kearsarge*. It measured 7½ feet in height and 16 feet in width and tapered from a thickness of 16½ inches to 9½ inches. The plate was set up with the thick edge of the plate down and the outer surface vertical, the center of the plate being normal with the line of fire. It was backed with 12 inches of oak and ½-inch skin plates. The plate was secured to the structure by six holding-in bolts, and the distance between gun and plate was 334 feet. In the first round a Carpenter shot weighing 500 pounds was fired from a 10-inch breech loading rifle. The striking velocity was 1,293 feet a second and the striking energy 5,802 foot-tons.

The projectile struck the plate and smashed to pieces, the head of the shot remaining in the plate. Fifty-nine fragments in all, weighing 78 pounds, were picked up in front of the plate. The effect upon the plate was slight and very local. The backing was uninjured and there was no apparent effect on the skin plates. The estimated penetration was four inches. The diameter of the splash was 10 inches and of the flaking 14 inches. The plate where it was flaked seemed to be of very fine quality. The plate was then attacked with a 10-inch Wheeler-Sterling armor-piercing projectile, weighing 500 pounds, which was of extreme hardness from the point to 1½ inches in rear of the bourrelet. The striking velocity was 1850 feet a second and the striking energy 11,877 foot tons.

The projectile smashed on the plate, the head remaining embedded. The projectile broke up much less than that of the first round, 32 pieces being found in front of the plate, their total weight being 353 pounds, and the largest piece weighed 53½ pounds.

The estimated penetration was 9 inches. The plate was dished at the edges of the flaking to about ¼ inch below the general surface. The backing was uninjured and the skin plates were slightly bulged out at the top edge, where the bolts were carried away in the previous round. The second armor bolt from the right edge in the center row was carried away, and the lead washers of the third and fourth bolts of the same row were sheared off. The excellent behavior of this plate resulted in the acceptance of the group of armor which it represented.

We have also received interesting particulars of the ballistic test of two protective deck plates, 1¾ inches in thickness, manufactured by the same company. They represented a group of plates which will form the protective deck of the United States battleships *Kearsarge* and *Kentucky*.

The plates were clamped at the ends without backing, and were set up in such a position as to make an angle of about 7° between them and the line of fire. A 6-inch gun, firing an armor piercing shell weighing 100 pounds, was used, and the shell was delivered with a striking velocity of about 1800 feet a second.

The first shot made a gouge in the plate about 27 inches long and dished it to the depth of about 3 inches. The shell was thrown off and was broken into a number of pieces, and the bulge at the back of the plate was uncracked. The result of the test of the second plate was similar to that of the first, except that the back bulge was slightly cracked. In this round, also, the shell was badly broken up. As neither plate showed any injury other than the gouge at the point of impact, they are justly considered to be of very fine quality.

The importance of such deck armor can scarcely be over-estimated. The flat trajectory of modern shells, due to their high velocity, will insure that the angle of impact, when they strike the protective deck, will be comparatively small. The chance of the shell being deflected is further increased by the arrangement of coal bunkers above the armor belt and in the wake of the boilers and machinery.—*Scientific American*, May 1, 1897.

A Recent Bethlehem Plate.

We referred recently to a successful test made at Redington, Pa., on a lot of *Kearsarge* and *Kentucky* armor plate produced by the Bethlehem Iron Company of South Bethlehem, Pa.

An interesting comparison between this Bethlehem plate and a famous Krupp plate tested in Russia has been compiled by Lieutenant J. F. Meigs of the Bethlehem Iron Company (see table on following page).

c. Powder and Explosives.

Notes on the Literature of Explosives.

Messrs. William Macnab and E. Ristori have carried out a long series of experiments with explosive compounds for the purpose of studying chemical reactions at high temperatures and pressures, and of elucidating certain constants relating chiefly to the specific heat of gases under such conditions, and a portion of their results is published in the *Proc. Roy. Soc.*, 56, 8-9, 1894, under the title of "Researches on Modern Explosives."

For these experiments they have principally used nitro-glycerine, nitro-cellulose, and several combinations of these two bodies which are used for smokeless gunpowders, for the reason that modern explosives offer the advantage of not only presenting comparatively simple chemical reactions, owing to the absence of solid residue, but also of enabling considerable variations to be made in their composition so as to vary the proportions of the elements reacting.

In this preliminary communication they propose chiefly to indicate the results obtained in the measurement of the heat evolved by explosion and of the quantity and composition of the gases produced by this metamorphosis.

They have also made considerable progress towards the determination of the actual temperature of explosion, and have succeeded in recording these high temperatures by photographic means, but these results are to be made the subject of another communication at an early date.

Details of plate.	Where made and fired at.	Projectile.	Velocity.	Total energy of blow in foot-tons.	Energy in foot-tons per square inch of button struck out of plate.	Energy in foot-tons per ton of plate.	Remarks.
10″ plate, representing first group *Kentucky-Kearsarge* armor.	Bethlehem. Fired at, at Redington, May 7 and 8, 1897.	8″ Holtzer A. P., 250 pounds.	2,07	7,527	30	613.5	Curved, 12′ 4″ × 5′ 8″. Penetration 12″; shot broken, not into backing; no cracks, but back of plate opened. This was third 8″ shot on this plate.
10″ tapered plate, representing *Poltava* armor.	Krupp's. Fired at, at Ochta, end of October, 1896.	8″ Perm A. P., 190 pounds.	2,135	6,010	23.9	401	12′ 2″ × 7′ 7″; half 10″ thick, half tapering to 5″. This was the first of two similar shots fired for acceptance test. Penetration 7.7″; no cracks, shot broken.
10″ tapered plate, representing *Poltava* armor.	Krupp's. Fired at, at Ochta, end of October, 1896.	8″ Perm A. P., 190 pounds.	2,487	8,152	32.4	562	This was fifth shot at plate above. Plate through cracked; shot broken through plate, and lodged in backing.

—*The Iron Age*, May 20, 1897.

The great secret of all these modern explosives seems to be that by suitable means they are made into a solid substance, thus avoiding any porosity, and it appears probable that by doing so even the most powerful explosive can be mastered, so that, burning regularly from the surface, the rate of combustion can be controlled so as to avoid detonation.

This constitutes the most striking feature of the modern smokeless gunpowders, especially of those containing nitro-glycerine. If certain sized cubes, strips or cords of such powders are fired in a certain gun and the length of this gun does not allow of sufficient time during the travel of the shot for the explosive to be entirely consumed, the unburnt residue of the charge will be found to be of the same shape, whether cubes, strips or cords, only reduced in size; thus proving the most perfect surface combustion of these explosives.

It is thus possible to determine accurately what quantity of explosive, and what surface of combustion for the same, will be required, in order to obtain certain results in a certain gun, thus avoiding waste of powder.

The insensitiveness of modern smokeless powder was illustrated on the occasion of a disastrous fire which occurred in May, 1890, at the factory of Avigliana, Italy, where large quantities of ballistite were manufactured. In one building twelve tons of this explosive were collected and various operations of manufacture were performed. By accident some of it took fire, and the whole quantity was burnt in a few seconds. Though this powder was made of nitro-glycerine and nitro-cellulose, and though the amount was so large that had it been black powder it would have caused destruction for many miles around, still there was no explosion of any kind; none of the machinery was in any way damaged, and the wood was barely charred.

The explosives used in these experiments can be divided into three classes:

1. Those consisting of nitro-lignin or nitro-cellulose (not gelatinized) mixed or impregnated with a suitable nitrate, and mixed with coloring matters and some other substances for the purpose of retarding the rate of combustion.

2. Those consisting of purified nitro-lignin or nitro-cellulose gelatinized by a suitable process, and with or without the addition of nitro-benzene or other suitable nitrates.

3. Those consisting of nitro-cellulose combined with nitro-glycerin, with the addition of aniline, camphor, vaseline, or other kindred substances.

The experiments were carried out in two closed vessels of different dimensions and construction—a large one capable of standing high pressures and a small one for calorimetric work.

The large one consists of a steel cylinder of great thickness, closed at both ends by conical screw-plugs. One plug is provided with a crusher-gauge of the well known pattern, by which the compression of a small cylinder of copper serves to measure the pressure developed. The other plug is provided with an insulated conical core, by means of which an electric current can be passed for the purpose of firing the charge. A small hole on the side of the cylinder, bushed with iridium-platinum and closed by a coned screw-plug, serves to control the escape of the gases produced by the explosion. The capacity of the chamber was carefully measured and was found to be 247.6 cc.

The small vessel is of the same pattern as used by Berthelot, and was made by Golaz, of Paris. It has given great satisfaction and is in excellent order, although it has been used for more than two hundred explosions. This bomb, which is made of mild steel is cylindrical in shape, consists essentially of three parts—a bowl; a conical lid, which is accurately ground into the bowl; and a tightening cap, which screws on to the bowl over the lid. There is a small hole in the lid provided with a delivery tube, which can be opened and closed by means of a finely threaded conical plug. There is also an insulated platinum cone inserted from underneath in the lid, which admits of the charge in the bomb being fired by a platinum wire heated to redness by electricity. From the lid depend platinum supports which carry a platinum capsule, in which the explosive is placed and suspended in the middle of the chamber. The capacity of this bomb is 488 cc., and the total weight, including a small stand, when ready for immersion in the calorimeter, is 5633.28 grams.

The calorimeter is made of thin sheet brass, and a helicoidal stirrer of the same metal (Berthelot's pattern), driven by a small electromotor during the experiment, serves to thoroughly mix the water. The calorimeter stood in the center of an annular water-jacket covered with felt. The quantity of water used in the calorimeter each time was 2,500 grams, and the equivalent in water of the bomb, stirrer and calorimeter, due allowance having been made for the different specific heats of the different metals, is 623.4 grams.

The different thermometers employed were specially made by Casella, capable of being read to 0.005 of a degree cetigrade, and the weights of their stems, bulbs and mercury were known.

Various experiments were made in the large vessel, especially for the purpose of determining the pressure of the gases under different densities of charge. These trials were carried out in a field, the bomb being lowered into a hole in the ground before firing. Various difficulties were encountered, and in one experiment considerable damage was done by the heated gases effecting their escape at the moment of explosion and "washing away" part of the thread of one of the screw-plugs.

With the density of loading of $\triangle = 0.1$, *i. e.*, with a charge of 24.76 grams, the average of the pressures measured was 6.3 tons per square inch; with density $\triangle = 0.2$ the pressure rose to 15 tons, and with $\triangle = 0.3$ the pressure increased to 25 tons. These results are very similar to those published by Sir A. Noble, F. R. S.

With the small bomb were ascertained the amount of heat generated by the explosion, the volume and composition of the permanent gases resulting, and the quantity of aqueous vapor produced. As most of the explosives contained no mineral matter beyond a trifling percentage of "ash," it has been possible to analyze them in this way, the products of explosion when calculated from the analysis and volume of permanent gas and aqueous vapor agreeing closely with the weight of matter in the bomb before firing. A few of the explosives left a carbonaceous or mineral residue, but these will be specially noticed further on in connection with the table of the results.

The heat evolved was measured by placing the bomb containing the charge of explosive in the calorimeter containing 2,500 grams of water, and it was arranged that the temperature of the air, the water-jacket, and the calorimeter closely approximated each other. The stirrer was set in motion, and the thermometer in the calorimeter was read with a kathetometer. Observations of the temperatures were made every minute for the five minutes preceding the firing of the charge, and continued at intervals of a minute until the maximum was reached and for five minutes longer. The correction for loss of heat due to radiation of heat during the experiments amounted in general to about 0.01 of a degree. The increase in temperature varied from about 1° to 2½° C., according to the charge and explosive used.

The gas generated by the explosion was passed through weighed drying tubes connected with the valve on the lid of the vessel, and then collected and measured in a calibrated glass cylinder over mercury. The reading of the barometer and thermometer was noted, and the volume reduced to 0° C. and 760 mm.

The water was determined by immersing the bomb in a vessel containing boiling water. A three-way glass stop-cock intervened between the valve of the bomb and the drying tubes, and the other end of the drying apparatus was connected with a water vacuum pump.

The other branch of the three-way tap was connected with a separate drying apparatus. When the water surrounding the bulb was boiling, by starting the vacuum pump the steam and water were drawn into the absorbing apparatus; after a good vacuum had been made in the bomb the three-way tap was turned so that dry air rushed in, then connection was made with the drying apparatus, the bomb again exhausted, and so on, alternately, until (as experience showed) all the water had been removed from the bomb and collected in the drying tubes, which were then weighed. The weights of water thus obtained were calculated for comparison into volumes of H_2O gas at 0° C. and 760 mm.

The analyses of gas were carried out in duplicate in Dittmar's apparatus as improved by Lennox.

In most of the experiments the bomb, previous to firing, was exhausted and the amount of residual pressure, varying from 24 to 40 mm., noted on closing it. The amount of air corresponding to these pressures left in the bomb has the effect of increasing the heat generated by a small quantity amounting to five to seven calories. This quantity being within the limits of error of the calorimetric observation, no correction was made for the same, but the quantity of residual air was taken into account when comparing the weights of the products found with the weight of explosive used. Thus in tables I and II the volumes of gas of the given composition and of aqueous vapor were obtained from the given weight of explosive increased by the weight of the air corresponding to the vacuum indicated. When firing in an exhausted bomb it was found necessary to have the explosive surrounding the firing wire in comparatively small pieces, in order to ensure ignition of the whole charge.

Table I gives the principal results obtained with the several gunpowders above mentioned, tables II and III give the results obtained with samples of ballistite made with different proportions of the component parts, table IV indicates the effect of firing different weights of the same explosive in a closed vessel from which the air has not been exhausted, and table V gives the original elementary composition of several explosives compared with the products of combustion, both being represented as weights.

With the exception of the results given in table IV, all the others were obtained from the firing of 4 grams of the explosive.

In tables I and II we have expressed the results of firing some powders now in use, as well as certain specially prepared powders, so as to show the quantity of heat and the volumes and analysis of the gases produced, and have in the column headed "Coefficient of potential energy," given figures which serve as a measure of comparison of the power of the several explosives. These figures are the products of the number of calories by the

TABLE I.—INDICATING THE QUANTITY OF HEAT, ALSO THE VOLUME AND ANALYSIS OF THE GAS DEVELOPED PER GRAM WITH DIFFERENT SPORTING AND MILITARY SMOKELESS POWDERS NOW IN USE.

Name of explosive.	Calories per gram.	Permanent gases.	Aqueous vapor.	Total volume of gas calculated at 0° and 760 mm.	Per cent. composition of permanent gases.					Coefficient of potential energy.
					CO_2.	CO.	CH_4.	H.	N.	
		Cc. per gram.	Cc. per gram.	Cc. per gram.						
EC powder, English	800	420	154	574	22.9	40.6	0.5	15.5	20.5	459
SS sporting powder, English	799	584	150	734	18.2	45.4	0.7	20.0	15.7	586
Troisdorf, Germ'n	943	700	195	895	18.7	47.9	0.8	17.4	15.2	844
Rifleite, English	864	766	159	925	14.2	50.1	0.3	20.5	14.9	799
BN, French	833	738	168	906	13.2	53.1	0.7	19.4	13.6	755
Cordite, English manufacture	1253	647	235	882	24.9	40.3	0.7	14.8	19.3	1105
Ballistite, German manufacture	1291	591	231	822	33.1	35.4	0.5	10.1	20.9	1061
Ballistite, Italian and Spanish manufacture	1317	581	245	826	35.9	32.6	0.3	9.0	22.2	1088

TABLE II.—INDICATING THE QUANTITY OF HEAT, ALSO THE VOLUME AND ANALYSIS OF THE GAS DEVELOPED PER GRAM WITH NITRO-GLYCERIN, NITRO-CELLULOSE, AND WITH SEVERAL DIFFERENT COMBINATIONS OF THESE TWO EXPLOSIVES MADE AT ARDEER FACTORY.

Composition of explosive.	Calories per gram.	Permanent gas.	Aqueous vapor.	Total volume of gas calculated at 0° and 760 mm.	Per cent. composition of permanent gases.						Coefficient of potential energy.
					CO_2.	CO.	CH_4.	O.	H.	N.	
		Cc. per gr'm.	Cc. per gr'm.	Cc. per gram.							
A. Nitro-glycerin.	1652	464	257	741	63.0	..	..	4.0	..	33.0	1224
B. Nitro-cellulose (nitrogen = 13.30 per cent.)	1061	673	203	876	22.3	45.4	0.5	..	14.9	16.9	929
C. 50% nitro-cellulose (N = 12.24%) 50% nitro-glycerin.	1349	568	249	817	36.5	32.5	0.2	..	8.4	22.4	1102
D. 50% nitro-cellulose (N = 13.3%.) 50% nitro-glycerin.	1410	550	247	797	41.8	27.5	..	..	6.0	24.7	1124
E. 80% nitro-cellulose (N = 12.24%.) 20% nitro-glycerin.	1062	675	226	901	21.7	45.4	0.1	..	15.7	17.1	957
F. 80% nitro-cellulose (N = 13.30%) 20% nitro-glycerin.	1159	637	227	864	26.6	40.8	0.1	..	12.0	20.5	1001
G. 35% nitro-cellulose (N = 13.30%.) 5% vaseline. 60% nitro-glycerin.	1280	627	236	863	26.7	39.8	0.5	..	12.8	20.2	1105

TABLE III.—SHOWING THE HEAT DEVELOPED BY EXPLOSIVES CONTAINING NITRO-GLYCERIN AND NITRO-CELLULOSE IN DIFFERENT PROPORTIONS.

Composition of explosives.			Calories per gram.
Nitro-cellulose (N = 13.3 per cent).		Nitro-glycerin.	
100 per cent (dry pulp).		0	1061
100 “ “ (gelatinized).		0	922
90 “ “		10 per cent.	1044
80 “ “		20 “ “	1159
70 “ “		30 “ “	1267
60 “ “		40 “ “	1347
50 “ “		50 “ “	1410
40 “ “		60 “ “	1467
0 “ “		100 “ “	1652
Nitro-cellulose (N = 12.24 per cent).		Nitro-glycerin.	
80 per cent.		20 per cent.	1062
60 “ “		40 “ “	1288
50 “ “		50 “ “	1349
40 “ “		60 “ “	1405
Nitro-cellulose (N = 13.3 per cent).	Vaseline.	Nitro-glycerin.	
55 per cent.	5 per cent.	40 per cent.	1134
35 “ “	5 “ “	60 “ “	1280

volumes of gas, the last three figures being suppressed in order to simplify the results.

In the case of EC and SS a certain amount of mineral residue was left but this was not determined.

Troisdorf leaves a slight, and Rifleite and BN a considerable, carbonaceous residue, part of it adhering so tenaciously to the bomb that an exact determination was not made.

In the other experiments recorded in Tables I and II the degree of accuracy of the results may be gauged by the fact that the average weight of the products of explosion, calculated from the results found, amounts to 99.7 per cent. of the weight of the explosive fired, the extreme limits being 100.5 and 98.8 per cent.

In Table II the comparison of the pairs of results from explosives made with lower and more highly nitrated-cellulose shows that the use of the highly nitrated cellulose increases the quantity of heat developed and diminishes the volume of gas. The composition of the permanent gases is so altered, as might be expected, there being an increase in carbon dioxide and decrease in carbon monoxide and hydrogen.

The similarity in the volumes of gas produced and the composition of the permanent gases in the case of experiments F and G, is worthy of note when the great difference in the original component ingredients of the explosives is borne in mind.

Table III shows clearly the increase of heat due to increased percentage of

TABLE IV.—SHOWING THE HEAT DEVELOPED AND THE ANALYSIS OF THE PERMANENT GAS PRODUCED IN A CLOSED VESSEL FROM WHICH THE AIR HAS NOT BEEN EXHAUSTED—THE EXPLOSIVE BEING IN EVERY CASE BALLISTITE OF ITALIAN MANUFACTURE.

Charge.	Calories per gram.	Analysis of the permanent gas.			
		CO_2.	CO.	H.	N.
2 grams	1587	37.0	17.6	3.2	42.2
3 "	1485	36.4	22.0	4.6	37.0
4 "	1446	36.2	24.6	6.1	33.1
5 "	1415	36.2	26.0	7.2	30.6
6 "	1380	36.3	27.0	7.9	28.6

Traces of CH_4 were found, but in this series of experiments the quantity of this gas was not determined.

TABLE V.—SHOWING THE ORIGINAL COMPOSITION AND METAMORPHOSIS OF NITRO-CELLULOSE, NITRO-GLYCERIN, AND OF SEVERAL GUNPOWDERS MADE BY COMBINATIONS OF THESE TWO EXPLOSIVES.

Nature and description of explosives.	Per cent composition by weight.				Per cent products of combustion by w'ght.						
	Carbon, C.	Oxygen, O.	Hydrogen, H.	Nitrogen, N.	Carbonic acid, CO_2.	Carbonic oxide, CO.	Marsh gas, CH_4.	Oxygen, O.	Hydrogen, H.	Nitrogen, N.	Water, H_2O.
A. Nitro-glycerin.	15.7	63.0	2.3	18.8	57.6	..	..	2.7	..	18.8	20.7
B. Nitro-cellulose (nitrogen = 13.3).	24.58	57.68	2.73	13.6	29.27	38.52	0.24	..	0.86	13.6	16.30
C. 50% nitro-cellulose (N = 12.24%). 50% nitro-glycerin.	21.15	60.67	2.67	15.58	41.0	23.1	0.08	..	0.4	15.58	20.01
D. 50% nitro-cellulose (N = 13.30%). 50% nitro-glycerin.	20.47	61.23	2.49	16.35	45.3	19.0	..	..	0.3	16.35	19.90
E. 80% nitro-cellulose (N = 12.24%). 20% nitro-glycerin.	24.37	58.98	2.98	14.0	28.9	38.4	0.05	..	1.0	14.0	18.2
F. 80% nitro-cellulose (N = 13.30%). 20% nitro-glycerin.	23.11	58.98	2.71	15.84	33.4	32.6	0.04	..	0.7	15.84	18.2
G. 35% nitro-cellulose (N = 13.30%). 5% vaseline. 60% nitro-glycerin.	22.2	59.0	2.88	15.46	33.0	31.3	0.2	..	0.7	15.46	19.0
H. Cordite, English manufacture.	22.91	57.72	2.95	15.19	31.76	32.68	0.32	..	0.86	15.19	18.08
K. Ballistite, Italian and Spanish manufacture.	21.47	60.83	2.68	15.80	41.11	23.76	0.12	..	0.47	15.8	19.69

nitro-glycerin, as well as the difference of heat evolved from explosives containing nitro-cellulose of different degrees of nitration.

The diminution in quantity of heat (about 200 calories) which the replacement of 5 per cent. of nitro-cellulose by vaseline makes is also very striking.

Table IV shows the part played by the oxygen of the air in the bomb: when a smaller proportion of explosive in comparison with the air is present the combustion is more complete, and the heat evolved is greater and the composition of the gases is correspondingly modified.

Table V, the elementary composition of some of the explosives, along with the percentage composition of the products of explosion by weight, is given.

The composition of the samples has been calculated from the "bomb" analyses; as an example, one of the explosives and its decomposition may be represented approximately by the following equation.

They have assumed the nitro-cellulose to consist of a mixture of di- and tri-nitro-cellulose in proportion corresponding to the nitrogen as found by analysis.

The equation for experiment C may be taken as follows:

$$\overbrace{6\,[C_3H_5(NO_3)_3]}^{\text{50 per cent nitro-glycerin.}} + \overbrace{2\,[C_6H_7(NO_3)_3O_2] + 3\,[C_6H_8(NO_3)_2O_3]}^{\text{50 per cent. nitro-cellulose (N = 12.3 per cent.).}} = 25\,CO_2 + 23CO + 8H + 30N + 30H_2O.$$

The composition of this explosive, calculated from the foregoing formula and found by analysis, is as follows:

	Formula.	Analysis.
C	21.2	21.15
O	60.8	60.67
H	2.5	2.67
N	15.5	15.58
	100.0	100.07

These are some of the principal features noticeable in a preliminary survey of these experiments. They are continuing their investigations on the lines indicated in the paper, and are especially endeavoring to measure the actual temperature of explosion under varying conditions, and it is hoped that the result obtained will throw some light on the chemical and physical properties of many gases at high temperatures and under considerable pressures, and, at the same time, be useful in the practical application of explosives.

—*Proceedings of the U. S. Naval Institute*, 1896.

GENERAL MILITARY MATTERS.

The Penetration of Bullets of the Portuguese Rifle.

In the first two numbers of the *Revista de Engenheria Militar* (July and August, 1896), Nogueira de Campos, Captain of Engineers, gives a detailed account of some experiments made at the Portuguese School of Practical Engineering, from 1893 to 1896, for the purpose of determining the penetration of the bullet of the new model rifle in different materials, and also the necessary thickness to be given to various obstacles in order to insure the protection of troops.

This rifle, model 1886, is 8 mm. (.315 in.) in caliber and smokeless powder (Barreto Cartridge, B) is used with it. However, a certain number of shots were fired using the 1889 cartridge (ordinary powder O). The range adopted was generally 50 m. (164 feet).

A. ***Brick walls*** (built with ordinary lime mortar ½, one month before the experiments).

1. Ordinary wall, 11 cm. (4.3 in) thick. The wall was shot through in two shots with powder *O*, and in one shot with powder *B*.

2. Ordinary wall, 22 cm. (8.6 in.) thick. A single shot penetrated about 5 to 8 cm. (1.96 to 3.15). Nine shots fired together over a surface 15 cm. (5.89 in.) in diameter, pierced the wall. The bullets penetrated more easily in the joints than in the bricks.

3. Wall 11 cm. (4.3 in.) thick, revetted on the side towards the gun with an iron plate 4 mm. (.157 in.) thick. With powder *O*, the bullet went through the plate, but remained in the wall. With powder *B*, the wall was pierced after two rounds.

4. Wall 11 cm. thick, iron plate 6 mm. (.236 in.) on the side towards the gun. From 5 to 8 rounds (powder *B*) fired together over a surface 10 to 15 cm. (3.93 to 5.89 in.) in diameter were necessary to pierce the wall through and through.

5. Wall 11 cm. thick, iron plate 4 mm. (.157 in.) thick, on the farther side. A volley of 5 shots was required to pierce the wall; the resistance is greater than in case 3.

6. Wall 11 cm. thick, a 6 mm. (.236 in.) iron plate on the farther side. A volley of 15 shots (powder *B*) over an area 20 cm. (7.87 in.) in diameter, was needed to pierce the whole.

7. Wall 11 cm. thick revetted with two iron plates, a 1 mm. (.039 in.) plate on the side towards the gun, a 2 mm. (.078 in.) one on the farther face. A volley of 8 shots (powder *B*) over a surface of 20 cm. (7.87 in.) diameter was necessary for perforation. The corresponding part of wall between the two plates was almost cleaned away.

8. Wall 22 cm. (8.6 in.) thick, a 4 mm. (.157 in.) iron plate on the face towards the gun. A volley of 19 shots (18×24 cm$^2 = 66.94$ sq. in.) merely made ordinary holes in the plate, 10 mm. (.393 in.) in diameter, and an excoriation 14 cm. (5.51 in.) deep in the wall.

9. Wall 11 cm. thick, two iron plates, 2 mm. (.078 in.) and 3 mm. (.118 in.). It took a volley of 15 shots to pierce the wall. This result followed only after the brick between the two plates had been broken up and carried away through the holes.

B. *Pisé walls* [clay held in place, built in layers of 10 cm. (3.93 in.)—Powder *B*].

1. Walls 20 cm. (7.87 in.), one month old, revetted on both sides with planks (*madriers*).* Perforated after 8 rounds, grouped over 8 cm. (3.15 in.).

2. Wall 30 cm. (11.81 in.) thick, one month old, revetted on both sides with planks (*madriers*). One shot penetrated from 24 to 25 cm. (9.44 to 984 in.). Perforated after 9 rounds, grouped over 9 cm. (3.54 inches).

3. Wall 30 cm., 1 year old without revetment: One bullet penetrated about 10 cm. (3.94 in.); 10 rounds, grouped over 15 cm. (5.90 in.) perforated it.

4. Wall 40 cm. (15.75 in.), one month old, without revetment: One bullet penetrated from 15 to 16 cm. (5.9 to 6.29 in.).

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* Planks from .03 m. to .05 m. in thickness; used in making the road-bed of bridges or the platform for siege pieces. Also used in the construction of bomb-proofs, and for revetting the sides of embrasures, etc.

5. Wall 40 cm., one year old.
about 10 cm. (3.94 in.), the 15th r

6. Wall 40 cm., one month
both faces; one bullet penetrated
rounds, grouped over 22 cm. (8.66 in.

7. Wall 70 cm. (27.56 in.), one m
penetrated about 11 cm. (4.33 in.).

*C*₁. *Walls of high grade béton* (P
material).

1. Wall 10 cm. (3.94 in.), revetted
béton 10 days old. One bullet went th
joint in the planking. Eight rounds, gr
sary to perforate the wall.

2. Wall 10 cm., revetted on the front
on the rear with planks (*madriers*);
about 9 cm. (3.54 in.). 25 rounds, group
it but incompletely, the planks on the ba

3. Wall 10 cm. revetted with planks (*m*
a 4 mm. (.157 in.) iron plate on the
rounds grouped over 13 cm. (5.12 in.).

4. Wall 15 cm. (5.90 in.), planking (*ma*
16 rounds grouped over 12 cm. (4.72 in.) pe
in.).

5. Wall 20 cm. (7.87 in.), without revetme
round, grouped over 16 cm. (6.3 in.).

6. Wall 30 cm. (11.81 in.), without revetm
12th round, grouped over 15 cm. (5.9 in.).

7. Wall 10 cm., one year old, revetted with
Perforated after 9 rounds, grouped over 12 x 7

8. Wall 20 cm., without revetment, one yea
10 cm. (3.94) in.) made only an excavation about

*C*₂. *Walls of ordinary béton* (Portland cement
terial).

1. Wall 20 cm. (7.87 in.), without revetment,
14 rounds, hits grouped over 18 cm. (7.08 in.).

2. Wall 30 cm. (11.81 in.), without revetment,
hole 13 cm. (5.12 in.) deep was made after 20 ro
(10.24 in.).

3. Wall 15 cm. (5.9 in.), without revetment, one y
trated about 5 cm. (1.97 in.); 5 formed a funnel abou
ter and 8 cm. (3.15 in.) in depth. The wall was per

*D*₁. *Iron Plates*, 6 + 4 mm. (.236 + .157 in.). Perfo
Same result with 10 mm. (.393 in.), with (6 + 6) mm., w
with (6 + 6 + 4) mm., and with (10 + 6) mm.

*D*₂. *Steel Plate* 10 mm. (.394 in.) thick (kind not sp
every round.

*D*₃. *Iron Bars*, 16 mm. (.63 in.) diameter. One bullet
to 12 mm. (.433 to 472 in.). Perforated after 6 rounds.

E. *Stockades* (*Palanques*).*

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* Palings from 3.5 m. to 4 m long formed of tree trunks at least .2 m.
square, and set close together in the earth to a depth of 1 m. or 1.5 m.

1. Timber 16 cm. (6.29 in.) with a parapet of earth 50 cm. (19.68 in.) thick. The bullets that directly struck the timbers, perforated them at the first round. Those that hit the parapet did not reach the timber even after 20 shots.

2. Timber 23 cm. (9.05 in.) diameter, without parapet of earth. Perforated at every round.

3. Double row of stockades (*palanques*), separated by 40 cm. (15.75 in.) of earth. Could not succeed in perforating it with 20 rounds.

—*Revue du Génie Militaire*, January, 1897.

Translated by Lieutenant ANDREW HERO, Jr., 4th Artillery.

General Table of Corrections for Quadrant Angles, for Distance of Gun Above or Below Target.

$$\varphi = \frac{H}{.000291\, R}$$

H = height in feet.
R = range in feet.
$.000291$ = tangent $1'$.

When above target subtract. When below add.

RANGE.		Curvature of earth. feet.	MINUTES.							
			Height.							
yds.	miles.		1 ft.	2 ft.	3 ft.	4 ft.	10 ft.	20 ft.	30 ft.	40 ft.
1000	0.568	0.215	1.14	2.29	3.43	4.58	11.45	22.91	34.36	45.82
1100	0.625	0.260	1.04	2.09	3.12	4.16	10.41	20.92	31.24	41.64
1200	0.681	0.309	0.95	1.90	2.86	3.81	9.54	19.09	28.63	38.18
1300	0.738	0.363	0.88	1.77	2.64	3.52	8.81	17.71	26.43	35.24
1400	0.795	0.421	0.82	1.64	2.45	3.27	8.18	16.36	24.55	32.73
1500	0.852	0.484	0.76	1.53	2.29	3.05	7.64	15.27	22.91	80.55
1600	0.909	0.551	0.72	1.43	2.15	2.86	7.16	14.32	21.48	28.64
1700	0.966	0.622	0.67	1.34	2.02	2.69	6.74	13.47	20.22	26.95
1800	1.02	0.694	0.64	1.27	1.91	2.54	6.36	12.73	19.09	25.45
1900	1.078	0.775	0.60	1.20	1.80	2.41	6.03	12.06	18.04	24.12
2000	1.134	0.860	0.57	1.15	1.72	2,29	5.73	11.45	17.18	22.88
2100	1.193	0.950	0.54	1.09	1.64	2.18	5.45	10.91	16.36	21.82
2200	1.25	1.04	0.52	1.04	1.56	2.08	5.21	10.41	15.62	20.83
2300	1.31	1.14	0.49	1.00	1.49	1.99	4.98	9.96	14.94	19.92
2400	1.36	1.23	0.47	0.95	1.43	1.90	4.77	9.55	14.32	19.09
2500	1.42	1.34	0.46	0.91	1.37	1.83	4.58	9.12	13.74	18.32
3000	1.70	1.93	0.38	0.76	1.15	1.52	3.82	7.64	11.46	15.28
3500	1.99	2.63	0.32	0.65	0.98	1.30	3.27	6.54	9.82	13.0
4000	2.27	3.44	0.28	0.57	0.86	1.14	2.86	5.72	8.59	11.45
4500	2.56	4.34	0.25	0.51	0.76	1.02	2.54	5.02	7.64	10.18
5000	2.84	5.38	0.23	0.46	0.69	0.91	2.29	4.58	6.87	9.16
5500	3.125	7.18	0.21	0.42	0.62	0.83	2.08	4.17	6.25	8.33
6000	3.41	7.75	0.19	0.38	0.58	0.76	1.91	3.82	5.73	7.64
6500	3.7	9.13	0.18	0.35	0.53	0.72	1.76	3.53	5.29	7.06
7000	3.98	10.56	0.16	0.33	0.49	0.65	1.64	3.27	4.91	6.55
7500	4.26	12.10	0.15	0.30	0.46	0.61	1.53	3.04	4.58	6.11
8000	4.55	13.80	0.14	0.29	0.43	0.57	1.43	2.86	4.30	5.73
8500	4.83	15.55	0.13	0.27	0.40	0.54	1.35	2.69	4.04	5.39
9000	5.11	17.41	0.13	0.26	0.38	0.51	1.27	2.55	3.82	5.09
9500	5.4	19.44	0.12	0.24	0.36	0.48	1.21	2.41	3.62	4.82
10000	5.68	21.51	0.12	0.23	0.35	0.46	1.15	2.29	3.44	4.58

The above table can be used to determine, with sufficient accuracy for all practical purposes, the allowance for all heights from 1 foot to 200 feet. Any height can be found by the combinations of the numbers 1, 2, 3 and 4 and 10, 20, 30 and 40, and the corresponding allowance be determined by adding up the tabular allowance.

The curvature of the earth should be allowed for at all ranges where it becomes appreciable, the target being that much below the horizontal plane of reference, thus increasing height of gun above target.

Curvature of the earth for all ranges in the table are given. These heights added to the height of gun above the horizontal plane of reference, give the true height of gun above target. The horizontal plane of reference generally being "mean low water," the state of the tide must be considered in all harbors affected by a great rise and fall of the tide.

The above corrections are for *quadrant angles alone* or their equivalent, such as the angles given by the graduation of gear wheel of elevating apparatus for disappearing guns. When tangent sight is used in direct laying the corrections do *not* apply, the correction being automaticallv applied in the act of laying the gun on the target. The above table will apply for all heights up to any probable height of gun above target.

1st Lieutenant C. D. PARKHURST, 4th Artillery.

BOOK REVIEWS.

Life of Napoleon Bonaparte, by William Milligan Sloane, Ph.D., L.H.D., Professor of History in Princeton University. Volume III. New York: The Century Co., 1897. Complete in four volumes; per volume, cloth, $7.00; half morocco, $8.00; three-quarter morocco, $9.00; full morocco, $12.50.

The third volume of this splendid work is quite equal in style and contents to the two preceding volumes; indeed, the illustrations comprise the most beautiful battle pictures in the world's history, while the subject-matter includes descriptions of Napoleon's grandest conceptions.

The account opens with the devastation of Prussia, following Jena and Auerstädt, and closes with the evacuation of Moscow. Eylau, Friedland, Eckmühl, Wagram and Borodino are here added to the list of his victories, while the liberation of Poland, the treaty of Tilsit, the protectorate of Portugal, the awakening of Spain, the peace of Schönbrunn, the Austrian marriage and the Confederation of the Rhine are the great political events here recorded.

The dramatic events crowded into the six years covered by this volume, 1807-1812, follow one another in rapid succession. The contest between the strategist and the statesman lead at one time to the weakest combinations, at another to the finest efforts of genius. The weakness of the battle of Friedland is explained by the fact that Napoleon desired merely to satisfy his army's eagerness for glory, and yet leave Alexander in a humor to unite with him for the gratification of his oriental ambitions, while Eckmühl stands out as the master-piece of this master-mind.

While the great schemer was planning the empire of the world the causes of his final overthrow become apparent. The devastation of Prussia led to the regeneration of that land, the humiliation of Spain caused an awakening of that country which ended in the retreat of the French, the Austrian marriage gave rise to the disastrous Russian campaign, and all these factors and others entered into the causes of the array of the nations against France.

Amid all these great scenes the biographer, true to his task, keeps before us the *man*, physically, mentally and morally.

The chapters on the leading events in state policy show the author in his best light, for his knowledge of the history of the time is second to none, and his understanding of the philosophy of history, his grasp of the true meaning of the scenes enacting is remarkable.

But the accounts of battles, while sufficient for the biographer, are unsatisfactory from the standpoint of the military student. Thus, the battle of Eckmühl, Napoleon's greatest, is thus briefly described:

"Charles, strengthened by this reinforcement had determined to take the offensive, and at noon his advance began. Vandamme seemed destined to bear the force of the onset, but in the moment before the shock would have occurred, appeared Napoleon's van. Advancing rapidly with Lannes, the Emperor rode to the top of a slight rise, and, scanning the coming Austrians, suddenly ordered Vandamme to seize Eckmühl, and then despatched Lannes to cross the Laber and circumvert the enemy. Davout, having learned the direction of the Austrian charge, threw himself against the hostile columns on their right, and after a stubborn resistance began to push back the dogged foe. In less than two hours the French right, left and center were all advancing, and the enemy were steadily retreating, but fighting fiercely as they withdrew. This continued until seven in the evening, when Lannes finally accomplished his task."

The illustrations in this volume include the finest in the entire collection, and among them may be mentioned Meissonier's "1807--Friedland," Detaille's "Vive L'Empereur," Royer's "Napoleon decorating the Prussian grenadier at Tilsit," Delaroche's "Napoleon in his study," Prudhon's "Josephine" and Gérard's "Joseph Bonaparte."

J.P.W.

Strategisch-taktische Aufgaben nebst Loesungen. Von H. v. Gizycki. Heft 1. Leipzig: Zuckschwerdt & Co., 1897. Pp. 88. 2.50 Marks.

This, the first number of this excellent series of tactical and strategical problems is already in its fifth edition, the latest changes having been made by the *Felddienst-Ordnung* of July 20, 1894.

The subject-matter of this number is the establishment of outposts, the advance across the border, the changes made in consequence of new information regarding the enemy and finally the defense of the position or the attack of the enemy; the whole discussed nnder seven separate problems.

The troops directly involved in the first problem are a battalion and a half-squadron, in the second problem an infantry regiment, a squadron, a battery and a pioneer company, in the third, fourth and fifth problems an infantry brigade, a cavalry regiment, three batteries, a pioneer company, a bridge train and an ambulance section, and in the sixth and seventh two brigades of infantry, a regiment of cavalry, six batteries, a pioneer battalion, a bridge train and an ambulance section.

The problems have been freely criticised by able officers and the solutions are therefore worthy of careful study.

The author says in conclusion :

"The problems which we have discussed are sufficient to show that no military situation can be met by formations according to fixed and definite models. If that were the case war would be a trade, not as it actually is—an art. In war the first step must be to subject the particular situation to careful investigation, and then to develop the decision as to the measures to be adopted from the conclusions arrived at, irrespective of the particular *wording* of any tactics or regulations."

The work contains three sketch maps and a general staff chart.

J.P.W.

Tactical Studies on the Battles around Plevna, by Thilo von Trotha. Translated by C. Reichmann, 1st Lieutenant, 9th Infantry. International Series, No. 3. Edited by Captain Arthur L. Wagner, 6th Infantry. Kansas City, Mo,: Hudson-KImberly Publishing Co. 1896. $1.50.

The particular interest which attaches to *recent* wars is largely due to the fact that in them the later developments in the art of war are put to the test, and therefore valuable data for present use are obtained.

The Turko-Russian war of 1877-8 was the last great conflict from which important military lessons are to be learned, hence the work before us has a special value. The great standard on the campaign, accessible to English readers, is the work of Captain F. V. Greene of our Engineers. Captain von Trotha's work, here presented in English for the first time, forms an excellent supplement to the former, and as such it is worthy of careful study.

After a brief review of the Danube Campaign and the operations around Plevna, the author takes up the subject of Plevna itself, the actions and battles in its vicinity, its assault, investment and final fall.

The Turko-Russian war developed two new factors of modern fighting—*fire of masses* and *field entrenchments*—and three great military commanders, —Skobeleff, Gourko and Kuropatkine.

In the battle of Plevna (July 30) the tactics of the Russians was remarkably faulty on account of the want of co-operation of the three arms.

"The *possibility* of co-operation of the three arms in unfavorable terrain is demonstrated by the small left flank detachment under General Skobeleff.

"The conduct of the action by this general shows a rare combination of prudence and rashness. His personal and thorough reconnaissance of the ground; his careful arrangements for guarding the rear of his detachment, and for maintaining communication with the main army; the bold advance of his small detachment close to the enemy's position, attracting disproportionately large forces of the enemy and rendering the attack of the main army correspondingly easier; his stout defensive action, in which infantry, artillery, and cavalry (both mounted and dismounted) supported one another with great skill; lastly, upon learning of the beginning of the main attack on the part of Shakofskoi's troops, his energetic offensive, for which he employed his heretofore carefully husbanded small infantry reserve, and the skillful and successful retreat under difficult circumstances—are certainly worthy of great consideration and thorough study."

The author has the same high praise for Skobeleff's conduct in the assault on Plevna (September 8-12).

The task of the Russo-Roumanian cavalry on the left bank of the Vid (September 7-19), to prevent reinforcements and supplies from reaching Plevna, failed entirely until Gourko took command. In regard to the Turkish attempt to break through the lines the author says:

"As long as a so-called relief army stood at Orkhanie, Osman's retreat, if difficult, was possible; but the fate of the army of Plevna was sealed as soon as Gourko's bold operations in the passes of the Balkans compelled the Turkish army at Orkhanie to fall back to Sophia."

Kuropatkine was Skobeleff's chief of staff, and was charged with the posting of the guns in the attack on Lovtcha. He has since risen to the rank of lieutenant-general, and is regarded as Skobeleffs natural successor.

It is remarkable how distinctly Skobeleff and Gourko stand out as able commanders among their brother officers.

The entire work, when studied in connection with Greene's completer history, furnishes a valuable commentary on the events. The translation has been excellently well done, but the one map accompanying the volume ls not adequate. The importance of these tacticai studies is sufficient to warrant their having a place in the International Series.

J. P. W.

Historischer Rückblick auf die Verpflegung der Armeen im Felde. II. Lieferung. Oberstlieutenant Otto Meixner, des Generalstabs-Corps, Lehrer an den Administrativen Militär-Fachcursen. L. W. Seidel & Sohn, Wien, 1897. Pp. 196. 2 Maps.

The second part of this unique work on the history of the supply of armies in the field, opens with an account of the Russian army and its system of supply up to 1853. then takes up the Crimean War, 1853-1856, and closes with the campaign in Italy in 1859.

The first subdivision of the subject forms the connecting link between the Napoleanic and the more recent wars. Up to 1812 the Russian troops entered the field with little or no system of supply, and the latter was usually limited to supplies of money and orders on the inhabitants. Whenever the Russian troops took part in European wars their supply usually fell on their allies. Between 1812 and 1815 they were enabled to draw from the inhabitants directly. In the Turkish campaigns, however, a system of supply had to be organized, and of this the author gives us a brief but interesting description.

The Crimean War is described from the Russian standpoint, and this adds an element which is of great interest to us, since the literature of the subject is not easily accessible. Although the earlier operations on the Danube *are* of secondary *military* importance, the system of supply developed was quite remarkable. There were ultimately forty-three supply magazines in Wallachia and Moldavia, with a main supply base on the Pruth and supply stations farther to the rear on the left bank of the Dneister. During the evacuation of the occupied district, when the supplies had to be taken behind the Pruth, over 1500 wagons left Buzen, Focsani and Tekucin daily for a period of one month, and there were on the road continuously four columns of wagons moving to and fro between the two stations. The Crimean War proper gives rise to still greater problems of supply on account of the great extent of the position occupied, the poor communications and the length of time the army spent in the same locality, and it is estimated that 180,000 wagons were in constant use in rear of the army for this purpose. Of all these systems of supply the author gives us detailed accounts.

The campaign of 1859 in Italy is presented from the Austrian standpoint, and in a more complete and thorough manner than the others, so far as the system of supply is concerned.

The difficulties of supply were greatly enhanced by the lack of energy in conducting the war, the army acting on the principle that the enemy should first develop his plans, and the measures necessary to meet him be then taken, in other words, giving him all the advantage of the initiative, resulting in many and unnecessary movements in advance and in retreat, and causing continual changes in supply stations.

The same systematic treatment of the subject, and the same clearness and conciseness of expression which characterize Part I, hold true for Part II. The completed work will form the standard of authority on the subject, and the parts thus far published are certainly of exceptionally high quality. The material heretofore scattered through the pages of large works on the campaigns considered, or appearing in fragments in various journals and magazines, has been collected and arranged in excellent form by the hand of one who has fully mastered the subject.

J. P. W.

Graphische Logarithmen-Tafeln von Anton Tichy, 1897. Wien: Verlag des Oesterr. Ingenieur- und Architekten-Vereines.

These *graphic logarithmic tables* consist of a number of columns separated alternately by heavy and light lines, two adjacent columns, separated by a light line and inclosed in heavy lines, constituting a pair belonging together, the left hand column corresponding to the numbers, the right hand to the logarithms. On the light line separating the two columns two scales, one from either side, meet, in appearance something like a scale of any kind and its vernier. Each scale has only such numbers as are necessary for quickly reading it.

Taking ten numbers, of five places each, I found the logarithms to five places by the graphic tables in eight minutes, while it took nine minutes to find the logarithms of the same numbers to six places by the ordinary tables. When it is remembered that I have used the ordinary tables for a number of years, while this is the first time I ever used the graphic tables the advantage of using the latter is apparent.

For the fifth place the scale in the graphic tables is subdivided by the eye. The ease and accuracy with which this can be done is shown by the fact that had the six place logarithms been expressed in five place logarithms, they would have been identical with those obtained from the graphic tables.

The first page contains the logarithms of numbers from 1 to 1000 to four places; the next ten pages the logarithms of numbers from 1 to 10,000 to five places. Then follow the usual tables of logarithmic sines, cosines, tangents, etc., all arranged on this same graphic principle.

These tables are exceedingly convenient for rapid work, and will be of inestimable value to the computer.

J.P.W.

A Young People's History of Virginia and Virginians. Dabney Herndon Maury. Richmond, Va.: B. F. Johnson Publishing Company. School Edition $0.75. Library Edition $1.00. Parlor Edition $1.50.

The author of this interesting school history is a man of varied experiences and accomplishments: Graduating from the Military Academy in 1846, he served in the Mexican War, where he was twice brevetted, and was severely wounded at the battle of Cerro Gordo. For five years he was on duty at the Military Academy, first as assistant professor of Geography, History and Ethics, then as instructor in tactics. After eight years of frontier duty he was appointed assistant adjutant-general, and at the breaking out of the civil war he went South. In 1887 he was sent as U. S. Minister to the United State of Colombia.

He is the author of several works. "Skirmish Drill for Mounted Troops" (1889), "Recollections of a Virginian," etc., which received deserved encomiums and had a large circulation.

The history is concise, accurate, convenient for study and reference, and very well illustrated. Its style is happy and interesting, and the *important* is carefully separated from the *unimportant*, and brought out so forcibly as to strike the youthful mind and make a lasting impression. It is written in a fair-minded and unprejudiced spirit, and its teachings are those of patriotism, courage, fortitude and integrity. The cause of the South is presented in a just and reasonable light, and the events of the war are recorded fairly for both sides. In this connection the author says in his Introduction :

"The Virginian of to-day, recognizing that the Union established by his fathers, founded upon the consent of the States, has, by the arbitrament of battle, been converted into 'an indissoluble Union of indestructible States,' is as loyal to the new Union and modified Constitution, to which he looks as the palladium of human liberty, as his fathers were to the old, and is ready to shed his blood in its defense."

We heartily recommend this little volume to the teachers and homes of Virginia, as well as to all who are interested in the history of the state that gave seven presidents to the United States, and for many years guided the current of public thought in the government of our country.

J. P. W.

Strategisch-taktische Aufgaben, nebst Lösugen, von H. v. Gizycki. Heft 7. Vorposten. Leipzig: Zuckschwerdt and Co. 1897.

The well-known and highly valued collection of problems of Colonel Gizycki is being subjected to complete revision at the hands of excellent tacticians. The present number (7) is the second edition, and is revised to conform to the *Felddienst Ordnung* of July 20, 1894. It relates to outposts and considers the case of a detachment of:

One brigade, 2 squadrons, 3 batteries; 1 pioneer company with division bridge train; 1 infantry ammunition section; 1 artillery ammunition section; 1 ambulance detachment; which secures its front by means of outposts.

The problem is made especially interesting by the use of cyclists (belonging to one of the regiments), and by varying the conditions of the weather, assuming warm weather, hot weather, continual rain with good and with poor discipline, and finally winter weather.

The problem constitutes an excellent study of the subject of outposts and will be very useful to the young officer, but in addition it will have an interest and value for the experienced officer, since it is evidently intended to illustrate the fact that no system of outposts should be based on a mere model, but must result from a careful consideration of the ground and the conditions. It departs from common views and practice in two material respects: (1) the cavalry is made *independent* at the outset, which ordinarily applies only to large bodies of cavalry, and (2) the detachment commander gives *too many orders* to the advance guard commander, *e. g.*, he is directed to bivouac in a certain locality, whereas such details are usually left to his judgment. A general map of the country and a detailed General Staff map accompany the pamphlet.

J. P. W.

The French War and the Revolution. William Milligan Sloane, Ph.D., L.H.D., Professor in Princeton University. New York: Charles Scribner's Sons. 1893. $1.25.

This book is the second of a series of four, entitled *The American History Series*, each of which, while complete in itself, forms part of a connected history of the United States down to our own time.

The ideal way to study history is first to obtain a general survey of the subject on a proper scale, and then work in the details as time permits or inclination prompts. The American History Series supplies this general survey, and the separate volumes have taken their place as authoritative on the epochs of our national history to which they refer.

The era covered by Professor Sloane's volume extends from 1756 to 1783, and comprises the old French war and the Revolution. These two wars, though seemingly independent, really form a single epoch in our history, because throughout this time the application of English principles to American condititions led to the evolution of a new theory of government, common exertion for the common welfare experienced a continuous development, and the people were learning the necessity of union and growing conscious of a common destiny.

"The chief end of this volume is to present a reasoned account of all the facts. During my studies I have had access to many original sources, some of them unpublished copies from the English and French archives. At the same time I have diligently used the results of trustworthy investigators wherever found." (Author's Preface).

The work aims, therefore, to present the *philosophy* of the history of this epoch, although in popular form, and it has accomplished its task in a manner more than satisfactory. The little volume contains a wonderful amount of valuable matter, necessarily condensed into small space, but still arranged with such system, and presented in such clear language, as to be exceedingly interesting, and with sufficient fulness to give an excellent picture of the events and their causes.

The appendix contains a bibliography, which, coming from such a student as Professor Sloane, is of especial value to the reader who desires to fill in the details, here and there, in the splendid outline which the author has here furnished him.

J. P. W.

What is the most practicable plan of sanitary organization for active service in the United States Army? By John Van Rensselaer Hoff, A.M., M.D., Major and Surgeon, U. S. Army.

The author, who has devoted much time and study to the organization of the medical corps for field service, discusses, in this interesting pamphlet the sanitary organizations of the various European armies as well as our own during the last war, and arrives at the following conclusions as an answer to the question considered.

"First. A regimental detachment, consisting of three medical officers, three non-commissioned officers, and five privates, should be organized *pari passu* with the regiment (three battalions, 1200 men)--0.9 per cent. This detachment, when properly equipped, would easily meet the current requirements of the regiment to which it was attached, and no further consideration would need to be given this point until the regiment had been brigaded and assigned to a division.

"Second. At the time requisition is made upon the several States for their quota of troops, the authorities should be notified that a certain percentage of the number enlisted must be for the sanitary corps, and that these are to be selected under the direction of the Surgeon-General of the State. The recruits for the sanitary corps should rendezvous at the State medical depots, for preliminary instruction and organization into bearer companies and field hospital detachments. The bearer company should consist of three medical officers, thirteen non-commissioned officers, one musician, and forty-seven privates; total, sixty-four. The field hospital detachment should consist of four medical officers, one other officer, thirteen non-commissioned officers, and twenty-eight privates; total, forty-six.

"A bearer company and a field hospital detachment should be raised for each three thousand troops furnished by a State—3.7 per cent."

Every detail of this plan is carefully considered in the article, the pros and cons fully set forth, and the reasons for its adoption in our service clearly stated.

J. P. W.

BOOK NOTICES.

[These books will be fully *reviewed* as space becomes available.]

Lectures on Explosives. Willoughby Walke, First Lieutenant, Fifth United States Artillery, Instructor U. S. Artillery School. Second edition. New York: John Wiley and Sons. London: Chapman and Hall, Limited. 1897. 8vo., cloth. 450 pages. $4.00.

Napoleon Bonaparte et les Généraux Du Teil, 1788-1794. Par le Baron Joseph Du Teil. Paris: Alphonse Picard et Fils, 82 Rue Bonaparte.

Complément du Mémorial de Sainte-Heléne Napoléon en Exil. Par le Docteur Barry E. O'Méara. 2 volumes. Paris: Garnier Fréres.

Ed.

INDEX TO CURRENT ARTILLERY LITERATURE.

PERIODICALS CITED.

Abbreviations employed in index are added here in brackets.

All the periodicals are preserved in the Artillery School Library, Fort Monroe, Virginia.

ENGLAND.

Aldershot Military Society. *Occasional.*
Aldershot. Copies 6d each.

Arms and Explosives. [*Arms and Ex.*] *Monthly.*
Effingham House, Arundel Street, Strand, London, W. C. Per year 7 s.

Army and Navy Gazette. [*A. and N. Gaz.*] *Weekly.*
3 *York Street, Covent Garden, London. Per year £*1 12 *s* 6 *d.*

Canadian Military Gazette. [*Can. Gaz.*] *Fortnightly.*
Box 2179 Montreal, Canada. Per year $2.00.

The Engineer. [*Eng.*] *Weekly.*
33 *Norfolk Street, Strand, London. Per year £*2 6 *d.*

Engineering. [*Eng'ing.*] *Weekly.*
35-36 *Bedford Street, Strand, London, W. C. Per year £*2 6 *d.*

Journal of the Royal United Service Institution. [*Jour. R. U.S.I.*] *Monthly.*
17 *Great George Street, London, S. W. Per year* 24 *s.*

Journal of the United Service Institution of India. [*Jour. U. S. I. India*] *Monthly.*
Simla, India. Per year $2.50.

Photographic Journal. [*Photo. Jour.*] *Monthly.*
12 *Hanover Square, London.*

Proceedings of the Institution of Civil Engineers. [*Proceedings I. C. E.*]
25 *Great George Street, Westminister, London.*

Proceedings of the Institution of Mechanical Engineers.
[*Proceedings I. M. E.*] 19 *Victoria Street, Westminister, London.*

Proceedings of the Royal Artillery Institution. [*Proceedings R. A. I.*] *Monthly.*
Woolwich, England.

Professional Papers of the Corps of Royal Engineers.
[*Prof. Papers Corps Royal Eng'rs.*]
Chatham, England.

Review of Reviews. [*Rev. of Rev. Austral.*] *Monthly.*
169 *Queen Street, Melbourne, Australia. Per year* 11 s. 6 d.

Transactions of the Canadian Institute. [*Trans. Canadian Inst.*]
58 *Richmond Street, Toronto, Canada.*

Transactions of the Canadian Society of Civil Engineers.
[*Trans. Canadian Soc. C. E.*]
Montreal, Canada.

Transactions of the East of Scotland Tactical Society.
[*Trans. E. of S. Tactical Soc.*]
51 *Hanover Street, Edinburgh, Scotland.*

Transactions of the Institute of Naval Architects.
[*Trans. Inst. Naval Architects.*]
5 *Adelphi Terrace, London, W.C.*

United Service Gazette. [*U. S. Gaz.*] *Weekly.*
4-6 *Catherine Street, Strand, London, W. C. Per year* £1 10*s* 6*d.*

FRANCE.

L'Avenir Militaire. [*Avenir.*] *Semi-weekly.*
13 *Quai Voltaire, Paris. Per year* 18 *Fr.*

Le Génie Civil. [*Génie C.*] *Weekly.*
8 *Rue St. Dominique, Paris. Per year* 45 *Fr.*

Journal des Sciences Militaires. [*Sciences Militaires*] *Monthly.*
Rue et Passage Dauphine 30, *Paris. Per year* 40 *Fr.*

La Marine Française. [*Marine F.*] *Semi-monthly.*
23 *Rue Madame, Paris. Per year* 30 *Fr.*

Mémoires et Compte Rendu des Travaux de la Société des Ingénieurs Civils.
[*Ingénieurs Civils.*] *Monthly.*
10 *Cité Rougemont, Paris. Per year* 36 *Fr.*

Mémorial des Poudres et Salpêtres. [*M. Poudres et S.*] *Quarterly.*
Quai des Grands-Augustins, 55, *Paris. Per year* 12 *Fr.*

Le Monde Militaire. [*Monde.*] *Fortnightly.*
76 *Rue de Seine, Paris. Per year* 6 *Fr.*

Revue d'Artillerie. [*R. Artillerie.*] *Monthly.*
5 *Rue des Beaux-Arts, Paris. Per year* 22 *Fr.*

Revue de Cavalerie. [*R. Cav.*] *Monthly.*
Berger Levrault et Cie, Rue des Beaux-Arts 5, *Paris. Per year* 33 *Fr.*

Revue du Cercle Militaire. [*Cercle.*] *Weekly.*
37 *Rue de Bellechasse, Paris. Per year* 27 *Fr.*

Revue du Génie Militaire. [*Génie M.*] *Monthly.*
8 *Rue Saint-Dominique, Paris. Per year* 27 *Fr.*

Revue d'Infanterie. [*R. Inf.*] *Monthly.*
11 *Place Saint André-des-Arts, Paris. Per year* 25 *Fr.*

Revue Maritime. [*R. Maritime.*] *Monthly.*
L. Baudoin, Rue et Passage Dauphine 30, *Paris. Per year* 56 *Fr.*

Revue Militaire de l'Etranger. [*Etranger.*] *Monthly.*
L. Baudoin, Rue et Passage Dauphine 30, *Paris. Per year* 15 *Fr.*

Revue Militaire Universelle. [*R. Univ.*] *Monthly.*
11 *Place Saint André-des-Arts, Paris. Per year* 25 *Fr.*

Le Yacht—Journal de la Marine. [*Yacht.*] *Weekly.*
55 *Rue de Chateaudun, Paris. Per year* 30 *Fr.*

GERMANY.

Allgemeine Militaer-Zeitung. [*A. M.-Zeitung.*] *Semi-weekly.*
Darmstadt. Per year 24 *M.*

Archiv fuer die Artillerie-und Ingenieur Offiziere. [*Archiv.*] *Monthly.*
Koch Strasse, 68-78, *Berlin*, *S. W.* 12. *Per year* 12 *M.*

Beiheft zum Militaer-Wochenblatt. [*Beiheft.*]
Koch Strasse, 68, *S. W.*, *Berlin.*

Deutsche Heeres-Zeitung. [*Heeres-Zeit.*] *Semi-weekly.*
Wilhelmstrasse 15, *Berlin.* *Per year* $6.00.

Internationale Revue. [*Int. Revue.*] *Monthly.*
Blasewitzer Strasse 15, *Dresden.* *Per quarter* 6 *M.*

Jahrbuecher fuer die deutsche Armee und Marine. [*Jahrbuecher.*] *Monthly.*
Mohren Strasse, 19, *Berlin*, *W.* 8. *Per year* 32 *M.*

Kriegswaffen. [*Kriegswaffen.*] *Monthly.*
Rathenow, *Germany.* *Per year* $4.50.

Marine Rundschau. [*Mar. Rundschau.*] *Monthly.*
Koch Strasse, 68-70, *Berlin.* *Per year* 3 *M.*

Militaer-Wochenblatt. [*Wochenblatt.*] *Fortnightly.*
Koch Strasse, 68, *Berlin*, *S. W.* 12. *Per Year* 20 *M.*

Militärische Rundschau. [*Mil. Rundschau.*] *Monthly.*
Zuckschwerdt & Co., *Leipzig.* *Per quarter* 4.75 *M.*

Stahl und Eisen. [*Stahl u. Eisen.*] *Fortnightly.*
Schadenplatz 14, *Düsseldorf.* *Per year* $5.00.

Umschau, Die [*Umschau.*] *Weekly.*
Frankfort a. M. *Per year* 10 *M.*

AUSTRIA.

Mittheilungen ueber Gegenstaende des Artillerie und Genie-Wesens.
[*Mitth. Art. u. G.*] *Monthly.*
Wien, *VI*, *Getreidemarkt* 9. *Per year* 1 *Fl.* 50 *Kr.*

Mittheilungen aus dem Gebiete des Seewesens. [*Seewesens.*] *Monthly.*
Pola. *Per year* 14 *M.*

Organ der Militaer Wissenchaftlichen Vereine. [*Vereine.*]
Wien I, *Stauchgasse No.* 4. *Per year*, 8-14 *numbers*, 6 *Fl.*

Zeitschrift des Oesterreichischen Ingenieur und Architekten Vereines.
[*Z. Architekten Vereines.*] *Weekly.*
I. Eschenbachgasse, *No.* 9, *Wien.* *Per year* 10 *Fl.*

SWITZERLAND AND BELGIUM.

Allgemeine Schweizerische Militaer-Zeitung. [*A.S.M. Zeitung.*] *Weekly.*
Basel, *Switzerland.* *Per year*, 8 *Fr.*

La Belgique Militaire. [*Belgique M.*] *Weekly.*
Rue St. Georges 32, *Ixelles*, *Belgium.* *Per year* 12.50 *Fr.*

Monatschrift fuer Offiziere Aller Waffen. [*Monatschr.*] *Monthly.*
Frauenfeld, *Switzerland.* *Per year* 5 *Fr.*, *plus postage.*

Revue de l'Armée Belge. [*A. Belge.*] *Bi-monthly.*
22 *Rue des Guillemins*, *Liège*, *Belgium.* *Per year* 13 *Fr.*

Revue Militaire Suisse. [*R. M. Suisse.*] *Monthly.*
Escalier-du-Marché, *Lausanne*, *Switzerland.* *Per year* 10 *Fr.*

Schweizerische Zeitschrift fuer Artillerie und Genie. [*S. Zeitschrift.*]
Monthly.
Frauenfeld, Switzerland. Per year 8 *Fr.* 20 *centimes.*

SPAIN, PORTUGAL AND SOUTH AMERICA.

Boletin del Centro Naval. [*Boletin.*] *Monthly.*
438 *Alsina, Buenos Aires, Argentina Republica. Per year* $11.00.

Circulo Naval,—Revista de Marina. [*R. de Marina.*] *Monthly.*
Casilla num. 852, *Valparaiso, Chili.*

Memorial de Artilleria. [*M. de Art.*] *Monthly.*
Farmacia, num. 13, *Madrid, Spain. Per year, U. S.*, $3.40.

El Porvenir Militar. [*Porvenir.*] *Weekly.*
258 *Calle Montevideo, Buenos Aires, Argentina. Per year* 10 $\$\frac{m}{n}$.

La Prensa Militar. [*Prensa.*] *Weekly.*
Reconquista 1034, *Buenos Aires, Argentina.*

Revista Cientifico-Militar. [*Cientifico M.*] *Semi-monthly.*
5 *Calle de Cervantes, Barcelona, Spain. Per year* 32 *Fr.*

Revista da Commissao Technica Militar Consultiva. [*R. da Commissao.*]
Bi-monthly. Praça da Republica N. 32, *Rio de Janeiro, Brasil.*

Revista de Engenheria Militar. [*Engenheria Mil.*] *Monthly.*
Quartel da Cruz dos Quatro Caminhos, Lisbon, Portugal. Per year 1 $ 800 *réis.*

Revista do Exercito e da Armada. [*Exercito.*] *Monthly.*
Largo de S. Domingos No. 11, *Lisbon, Portugal. Per year U. S.* $6.00.

Revista General de Marina, [*R. G. de Marina.*] *Monthly.*
56 *Calle de Alcalá, Madrid, Spain. Price U. S.* $4.45.

Revista Maritima Brazileira. [*R.M. Brazil.*] *Bi-monthly.*
Rue do Conseheiro Saraiva n. 12, *Rio de Janeiro, Brazil. Per year* $10.00.

Revista Militar. [*R. Mil. Portugal.*] *Semi-weekly.*
262 *Rua da Princeza, Lisbon, Portugal. Per year*, $2.60.

Revista Militar. [*R. Mil. Chile.*] *Monthly.*
Santiago, Chili.

HOLLAND AND SCANDINAVIA.

Artillerie-Tidskrift. [*Art. Tids.*] *Bi-monthly.*
Stockholm, Sweden. Per year, U. S., $1.75.

De Militaert Gids. [*M. Gids.*] *Bi-monthly.*
De Erven F. Bohn, Haarlem, Holland. Per year, U. S., $2.00.

Militaert Tidsskrift. [*M. Tids.*] *Bi-monthly.*
Copenhagen, Denmark. Per year, U. S., $2.50.

Norsk Militeert Tidsskrift. [*N. M. Tids.*] *Monthly.*
Christiania, Norway. Per year, U. S., $2.50.

RUSSIA.

Artilleriiskii Journal. [*Art. Journal.*] *Monthly.*
Furschtatskaia Ulitza, St. Petersburg, Russia.

Razviedchik. [*Razv.*]
KoloKolwaia Ulitza, No. 14, *St. Petersburg, Russia.*

Russkii Invalide. [*Invalide.*]
Wadisdinskia Ulitsa, No. 48, *St. Petersburg, Russia.*

ITALY.

Rivista di Artiglieria é Genio. [*R. Artig.*] *Monthly.*
Tipografia Voghera Enrico, Rome. Per year 30 *L.*

Rivista Marittima. [*R. Maritt.*] *Monthly.*
Rome. Per year 25 *L.*

UNITED STATES.

American Engineer and Railroad Journal. [*Eng. and Rail. Jour.*] *Monthly.*
47 *Cedar Street, New York City. Per year* $3.00.

American Journal of Mathematics. [*Jour. Math.*]
John Hopkins University, Baltimore, Md.

American Machinist. [*Amer. Mach.*] *Weekly.*
256 *Broadway, New York City. Per year* $3.00.

American Manufacturer and Iron World. [*Man. and Iron World.*] *Weekly.*
59 *Ninth Street, Pittsburgh, Pa. Per year* $4.00.

Annual of the Office of Naval Intelligence. [*Naval Intelligence.*]
Washington, D. C.

Army and Navy Journal. [*A. and N. J.*] *Weekly.*
New York City. Per year $6.00.

Army and Navy Register. [*A. and N. R.*] *Weekly.*
Washington, D. C. Per year $3.00.

Bulletin of the American Mathematical Society. [*Bulletin Math. Soc.*]
University Heights, New York City.

Cassier's Magazine. [*Cas. Mag.*] *Monthly.*
World Building, New York City. Per year $3.00.

Digest of Physical Tests. [*Digest.*] *Quarterly.*
1424 *N.* 9*th Street, Philadelphia. Per year* $1.00.

Electrical Engineer. [*Elec. Eng.*] *Weekly.*
203 *Broadway, New York City. Per year* $3.00.

Electrical Engineering. [*Elec. Eng'ing.*] *Semi-Monthly.*
214 *Monroe Street, Chicago, Ill. Per year* $1.00.

Electrical Review. [*Elec. Rev. N. Y.*] *Weekly.*
13 *Park Row, New York City. Per Year* $3.00.

The Engineer. [*Eng. N. Y.*] *Fortnightly.*
106-108 *Fulton Street, New York City. Per year* $2.50.

Engineering News and American Railroad Journal.
[*Eng'ing News and R.R. Jour.*] *Weekly.*
Tribune Building, New York City. Per year $5.00.

Engineering and Mining Journal. [*Eng. and Min. Jour.*] *Weekly.*
253 *Broadway, New York City. Per year* $5.00.

The Iron Age. [*Iron Age.*] *Weekly.*
96-102 *Reade Street, New York City. Per year* $4.50.

Journal of Electricity. [*Jour. Elec.*] *Monthly.*
421 *Market Street, San Francisco, Cal.*

Journal of the American Chemical Society. [*J. Chem. S.*] *Monthly*
Easton, Pa. Per year $5.00.

Journal American Society of Naval Engineers. [*A.S.N. Egrs.*] *Quarterly.*
Navy Department, Washington, D. C.

Journal of the Association of Engineering Societies. [*Eng. Soc.*] *Monthly*
257 *South Fourth Street, Philadelphia. Per year* $3.00.

Journal of the Franklin Institute. [*Frank. Inst.*] *Monthly.*
Philadelphia, Pa., Per year $5.00.

Journal of the Military Service Institution. [*Jour. M. S. I.*] *Bi-monthly*
Governor's Island, New York City. Per year $4.00.

Journal of the U.S. Cavalry Association. [*Jour. U. S. Cavalry*] *Quarterly.*
Fort Leavenworth, Kansas.

Journal of the Western Society of Engineers. [*W. Soc. Eng.*] *Bi-monthly.*
1737 *Monadnock Block, Chicago, Illinois. Per year* $2.00.

Marine Review. [*Mar. Rev.*] *Weekly.*
Cleveland, Ohio. Per year $2.00.

Military Information Division. [*Mil. Information Div.*] *Occasional.*
War Department, Washington, D. C.

Pennsylvania Magazine of History and Biography. [*Penn. Mag. of Hist.*]
Quarterly.
13 *Locust Street, Philadelphia. Per year* $3.00.

The Photographic Times. [*Phot. Times.*] *Weekly.*
60 *and* 62 *E.* 11*th Street, New York City. Per year* $5.00.

Physical Review. [*Phys. Rev.*] *Bi-monthly.*
Cornell University, Ithaca, New York. Per year $3.00.

Popular Science Monthly. [*Pop. Sc. Mo.*] *Monthly.*
72 *Fifth Avenue, New York City. Per year* $5.00.

Proceedings of the American Philosophical Society.
[*Proceedings of A. Phil. Soc.*]
104 *South Fifth Street, Philadelphia, Pa.*

Proceedings of the U. S. Naval Institute. [*Naval Inst.*] *Quarterly.*
Annapolis, Md. Per year $3.50.

Public Opinion. [*Pub. Opin.*] *Weekly.*
New York City. Per year $2.50.

Review of Reviews. *Monthly.*
13 *Astor Place, New York City. Per year* $2.50.

The Scientific American. [*Scien. Amer.*] *Weekly.*
361 *Broadway, New York City. Per year* $3.00.

Shooting and Fishing. *Weekly.*
293 *Broadway, New York City. Per year* $3.50.

Technology Quarterly. [*Tech. Quart.*] *Quarterly.*
Mass. Inst. of Tech. Boston, Mass. Per year, $3.00.

Transactions American Institute of Electrical Engineers.
[*Inst. Elec. Eng'rs.*] *Monthly.*
26 *Cortlandt Street, New York City. Per year* $5.00.

Transactions American Institute of Mining Engineers.
[*Trans. Inst. Min. Eng'rs.*]
P. O. Box 225, *New York City.*

Transactions of the American Society of Civil Engineers.
[*Proceedings A.S. Civil Eng'rs*]
127 *East* 23*d Street*, *New York City.*

Transactions of the American Society of Mechanical Engineers.
[*Trans. A. S. Mech. Eng'rs.*]
12 *West* 31*st Street*, *New York City.*

Transactions of the Society of Naval Architects and Marine Engineers.
[*Naval Architects and Marine Eng'rs.*]
12 *West* 31*st Street*, *New York City.*

The United Service. [*U. Serv.*] *Monthly.*
1510 *Chestnut Street*, *Philadelphia.* *Per year* $2.00.

Western Electrician. [*West. Elec.*] *Weekly.*
510 *Marquette Building*, *Chicago*, *Illinois.* *Per year* $3.00.

Wilson's Photographic Magazine. [*Phot. Mag.*] *Monthly.*
853 *Broadway*, *New York City.* *Per year* $3.00.

ORGANIZATION AND ADMINISTRATION.

Change and progress in military systems.—**Umschau**, March 6, 13; May 8 15.

Review of the development of the principal armies in 1896.—**M. Tids.** No. 3.

Supply department and the military railway system in the past and present. —**N. M. Tids.** 3.

The defense of coasts.—**R. de Marina**, April.

General staff service.—**Avenir**, April 20.

The chief command and the general staff.—**Avenir**, April 9.

The army: its employment in time of peace.—**A. and N. Reg.**, June 5, 12, 19, 26.

National Guard, U. S.—**Jour. M. S. I.**, July.

A well organized infantry.—**Jour. M. S. I.**, July.

Question of an artillery reserve.—**Jour. M. S. I.**, July.

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Relative advantages of voluntary and compulsory service.—**Jour. R.U.S.I.**, May.

Defects of our military financial system (England).—**U. S. Gaz.**, May 15.

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A Royal Marine reserve.—**A. and N. Gaz.**, May 29.

The British Army and Navy.—**Int. Revue**, May.

Reorganization of the cavalry of the line in the English army.—**Etranger**, May.

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The naval strength of England in the Indian Ocean.— **Cercle**, June 19.

The colonial troops of various European states.—**Mil. Rundschau**, June.

The army and colonization.—**Cercle**, June 5, 12, 19.

The French colonial troops.—**Wochenblatt**, May 1.

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Changes in the artillery (France).—**Mil. Rundschau**, May.

The regiments of the reserve (France).—**Monde**, May 1.

The *cadres* of the reserves and of the territorial army (France).—**Avenir**, April 23; May 7, 11, 14, 18, 21, 25; June 15.

The French navy.—**Eng.**, June 4.

The Navy and Parliament (France).—**R. Maritime**, March-April.

The organization of field artillery (when rapid-fire guns are adopted).—**Wochenblatt**, June 5.

The present status of field artillery.—**Jour. M. S. I.**, May.

The reorganization of the technical troops.—**Heeres-Zeit.**, May 12, 15.

The service of the supply of clothing in the German army.—**Etranger**, May.

The squadrons of the estafettes in Germany.—**Monde**, May 15.

New organization of the German infantry.—**Avenir**, May 14; **Etranger**, April.

The new German regiments and the French fourth battalions.—**Avenir**, May 25.

The German navy.—**Avenir**, March 9.

The strength of Austria.—**Pub. Opin.**, July 1.

Australian military defense.—**A. and N. Gaz.**, May 22.

The reorganization of the Italian army.—**Cercle**, June 26; **Avenir**, May 18, 21.

The Spanish army. **M. de Art.**, May.

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The Turkish army.—**Avenir**, April 27.

The military medical service of Turkey.—**Mil. Rundschau**, June.

The military systems of Greece and Turkey.—**Mil. Information Div.**, No. 14.

The Greek army.—**Avenir**, April 30.

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The Belgian army in 1897.—**Cercle**, May 22.

Organization of the Brazilian navy.—**R. M. Brazil**, April.

Mountain artillery (organization, instruction).—**Cientifico M.**, May 1.

Argentina and Chili, especially their armies and navies.—**Mil. Rundschau**, May.

The military medical service of Denmark.—**Mil. Rundschau**, April.

Bavarian military bridge equipage and regulations for pontoneers.—**Mitth. Art. und G.**, No. 6.

Modern naval expeditions and military transports.—**R. M. Brazil**, **March**, April.

Food supply during transport by rail and organization and functions of *stations haltes-repas*.—**Cercle**, May 29.

The transmission of orders.—**Avenir**, March 15.

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Tactical exercises.—**R. M. Suisse**, April 15.

Tactical theme No. 7.—**Monde**, June 1.

The results of two years work in the German army (tactics, maneuvers, etc.).—**R. Inf.**, June.

Remarks on the establishment of outposts in proximity to the enemy.—**Monde**, June 1, 15.

Frontier detachments.—**Exercito**, March, April.

Advantages and disadvantages of smokeless powder.—**Monde**, May 1.

Ammunition supply in foreign armies.—**Jour. M. S. I.**, May.

A great question: the resupply of ammunition.—**Avenir**, May 4, 7, 11, 14.

The new German tactics.—**Avenir**, January 29, February 2-26, March 2-30, April 2-23.

Present tendencies in the German infantry.—**Cientifico**, May 1.

Sharpshooters and the *mass* firing of infantry.—**Jahrbuecher**, June.

Fire tactics of infantry since 1793.—**Monatschr**, April.

On the sub-units of the infantry company.—**Exercito**, April, May.

Tactical application of field defenses.—**Aldershot Mil. Soc.**, March.

Study on rifle, model 1886 (tactics).—**R. Inf.**, May.

The proper rifle for war.—**Cientifico**, May 15.

The effects of infantry and artillery fire (German opinions).—**R. Artillerie**, April, May, June.

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Artillery tactics (the want of room for the corps artillery).—**Wochenblatt**, June 19; **Avenir**, June 29.

Modern artillery questions (tactics).—**Heeres-Zeit.**, April 17—May 5.

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The insufficiency in preparation (instruction) of our artillery (France).—**Avenir**, March 15.

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Notes on artillery, dictated by Napoleon at St. Helena.—**R. Artillerie**, June.

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Quick-fire artillery.—**Umschau**, January 16.

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The rôle of cavalry in screening troops.—**R. Cav.**, April, May.

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Fifth contribution to the geometry of naval tactics.—**R. Maritime**, March.

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The duties of the navy.—**U. S. Gaz.**, June 12.

The dangers of the initiative.—**Avenir**, April 30.

The true importance of the initiative.—**Mil. Rundschau**, May.

A defensive which seeks decisive results.—**Vereine**, No. 3.

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Offensive and defensive.—**Avenir**, May 21.

The defense of coasts.—**M. de Art.**, April.

The latest submarine devices and their rôle in the defense of coasts.—**Vereine**, No. 4.

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The Moravian Gate and its strategic value.—**Int. Revue**, June.

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Belgium's military situation.—**A. M.-Zeit.**, April 8, 12, 15, 19.

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The German method of conducting warfare in East Africa.—**Cercle**, May 8, 15, 22, 29.

The defense of Constantinople on the land side.—**Cercle, May 22.**

The peninsular of Normandy in the defense of France.—**R. Univ., May,** June.

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The combat between ships.—**R. Maritt.,** April.

Problems of naval strategy.—**R. M. Brazil,** April.

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Landing operations.—**Vereine,** No. 5.

The naval strategy of Germany.—**Yacht,** June 12.

The next naval war.—**R. de Marina,** April.

Short historical notes on modern naval war.—**Boletin, February, March.**

National study of military history.—**Jour. R. U. S. I., May.**

The professional study of military.—**Jour. R. U. S. I., June.**

The century's war indemnities.—**Pub. Opin.,** June 10.

History of the French infantry.—**R. Inf., May, June.**

The British army on the continent of Europe.—**Proceedings R. A. I., April.**

The British policy and the Eastern question.—**Rev. of Rev., June.**

Campaigns of the English in Egypt and the Soudan.—**R. Inf., May, June.**

The expedition to Lombok.—**Exercito,** March, April.

The Dongola expedition of 1896.—**Jour. R. U. S. I., June.**

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Bonaparte's first campaign.—**Mil. Rundschau,** April, June.

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The military relations of Italy in the past three years.—**Int. Rev., May.**

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Military notes on the Chino-Japanese war.—**Cercle, June 5, 12.**

The philosophy of the Greco-Turkish war.—**Marine F.,** May 15.

Introduction to the study of the present Turko-Greek war (**Von der Goltz**). —**Wochenblatt,** May 12, June 2.

The Turko-Greek war of 1897.—**Etranger,** May; **Int. Rev., June; Jour. R. U. S. I.,** May; **A. S. M. Zeit.,** April 22—June 12; **Avenir,** April 27—**June 18.**

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The history of the navy.—Mil. Rundschau, April, May, June.

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Proper military instruction.—Jour. M. S. I., May.

The moral education of the soldier.—Avenir, April 27.

General manual for general staffs in armies.—Monde, May 15. (Service of information).

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Note on the instruction of recruits in the German field artillery.—R. Artillerie, March.

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The progress in artillery in Germany and France.—**R. Mil. Portugal**, June 15.

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Three improved types of the Maxim automatic rapid-fire gun.—**Scien. Amer.**, June 5.

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The ballistic qualities of the rifle, model 1886.—**R. Infanterie**, June.

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Certain principles of General Brailmont on sea-coast fortifications.—**M. de Art.**, May.

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THE PROBABILITY OF HIT WHEN THE PROBABLE ERROR IN AIM IS KNOWN: WITH A COMPARISON OF THE PROBABILITIES OF HIT BY THE METHODS OF INDEPENDENT AND PARALLEL FIRE FROM MORTAR BATTERIES.

BY MANSFIELD MERRIMAN, PROFESSOR OF CIVIL ENGINEERING IN LEHIGH UNIVERSITY.

The term "probability of hit" means the probability of hitting a target when one shot is fired, or if several shots be fired the probability of hit multiplied by the number of shots gives the probable number of hits. In general discussions of the probability of hit the inaccuracy in aim is regarded merely as one of the accidental errors which cause the dispersion of the shots. It is here proposed to investigate the case where the probable error of shot dispersion under accurate aim is known, and where also the probable error of the aim under ordinary conditions has been determined. Thus for a mortar the former may be found by firing a number of shots with the same range and azimuth, while the latter may be ascertained by tests on the instruments which locate a floating target in range and azimuth.

The target is supposed to be a rectangular object floating on the water, and in the case of a ship it will be taken as a rectangle slightly shorter than the total length and about the same area as the deck. One of the sides of the target will be taken parallel to the plane of fire, and its length in range be designated by $2A$, while the width of the target in azimuth is denoted by $2a$.

Let r_1 be the probable error of shot dispersion in azimuth and R_1 that in range, as determined under circumstances of accurate aim. Let r_2 be the probable error of the designated position in azimuth and R_2 that in range, as determined from tests on the azimuth and range finders. Let a shot be fired with the intention of hitting the center of the target; it is required to find the probability of hit on the target or deck whose area is $4aA$.

A SMALL TARGET.

When a and A are very small a simple expression for the probability of hit may be established. Considering first the case of errors in azimuth, or those at right angles to the plane of fire, let h_1 and h_2 be the measures of precision in shot dispersion and in azimuth aim, these being connected with the probable errors by the relations $h_1 r_1 = \rho$, $h_2 r_2 = \rho$, where $\rho = 0.4769363$. Let the center of the small target be indicated by the azimuth finder as at a position whose error is x, then

$$y_1 = \pi^{-\frac{1}{2}} h_1 e^{-h_1^2 x^2} . \ 2a \qquad (1)$$

is the probability of hit on the strip $2a$ when the error x exists. But the probability of this error x in azimuth aim is

$$y_2 = \pi^{-\frac{1}{2}} h_2 e^{-h_2^2 x^2} dx. \qquad (2)$$

The product of these two probabilities gives the probability of hit on the strip whose width in azimuth is $2a$ and whose length in range is infinite, under the combined error of shot dispersion and ordinary aim, or

$$y = 2a \pi^{-1} h_1 h_2 e^{-(h_1^2 + h_2^2)x^2} dx \qquad (3)$$

is the probability of hit in azimuth for any error x in azimuth aim. Then the probability of hit when nothing is known about the error x is the sum of the probabilities of hit which can occur in the different independent ways, that is, the sum of all the possible values of (3). This sum is

$$q = 2a \pi^{-1} h_1 h_2 \int_{-\infty}^{+\infty} e^{-(h_1^2 + h_2^2)x^2} dx = \frac{2a h_1 h_2}{\pi^{\frac{1}{2}} \sqrt{h_1^2 + h_2^2}} \qquad (4)$$

Now let h_1 and h_2 be replaced by ρ/r_1 and ρ/r_2, and let $r_1^2 + r_2^2$ be represented by r^2, where r may be called the resultant probable error in azimuth. Then (4) becomes

$$q = \frac{2\rho a}{\pi^{\frac{1}{2}} \sqrt{r_1^2 + r_2^2}} = \frac{2\rho a}{\pi^{\frac{1}{2}} r} \qquad (5)$$

which is the probability of hit in azimuth for the small target.

By applying the above reasoning to errors in range similar equations result, a, r_1, r_2, being replaced by A, R_1, R_2; and

$$q' = \frac{2\rho A}{\pi^{\frac{1}{2}} \sqrt{R_1^2 + R_2^2}} = \frac{2\rho A}{\pi^{\frac{1}{2}} R} \qquad (6)$$

is the probability of hit in range for the small target.

Formula (5) gives the probability of hit for the small strip whose width in azimuth is $2a$ and whose length in range is infinity; and formula (6) gives the probability of hit for the small strip whose width in range is $2A$ and whose length in azimuth is infinity. To find the probability of hit for the area $2a \times 2A$ these expressions are to be multiplied together, and

$$Q = q\,q' = \frac{\rho^2}{\pi} \cdot \frac{4\,a\,A}{r\,R} = 0.2896\,\frac{a\,A}{r\,R} \tag{7}$$

is the probability of hit for the small target.

If the aim be always perfectly accurate, there being no errors in the azimuth and range finders, these formulas become

$$q_1 = \frac{2\,\rho\,A}{\pi^{\frac{1}{2}}\,r_1}, \qquad q'_1 = \frac{2\,\rho\,A}{\pi^{\frac{1}{2}}\,R_1}, \qquad Q_1 = \frac{\rho^2}{\pi} \cdot \frac{4\,a\,A}{r_1\,R_1} \tag{8}$$

which are the expressions given by the common theory where the probable errors in aim are not separately considered.

Although these formulas are strictly correct only when a and A are very small it may be shown that values computed from (5) and (6) are in error only one-half of one per cent when $a = \frac{1}{4}\,r$ and $A = \frac{1}{4}\,R$, and only two per cent when $a = \frac{1}{2}\,r$ and $A = \frac{1}{2}\,R$. Hence in many cases of target practice they can be safely used for numerical computations.

A LARGE TARGET.

Following a similar line of reasoning, formulas for the probability of hit for a target of any size may be deduced. Taking first the investigation for azimuth, let the center of the target be designated by the azimuth finder at a position whose error is x. The probability of this error is given by (2). Let z be any distance in azimuth from the middle of the target; then the probability of hit on the strip dz for this error x is

$$y_1 = \pi^{-\frac{1}{2}}\,h_1\,e^{-h_1^2\,(x\,+\,z)^2}\,dz\,, \tag{9}$$

and the product of (2) and (9) gives the probability of hit under the two combined causes of error. The sum of all possible values of this product is the probability of hit in azimuth for the strip dz. Then z must be varied so as to cover the whole width $2a$. Thus, the expression to be integrated is

$$q = \pi^{-1}\,h_1\,h_2 \int_{-a}^{+a} \int_{-\infty}^{+\infty} e^{-h_1^2\,(x\,+\,z)\,-h_2^2\,x^2}\;dz\;dx, \tag{10}$$

where $-\infty$ and $+\infty$ are the limits for x, and $-a$ and $+\,a$ are the limits for z. Let u represent $h_1 h_2 (h_1^2 + h_2)^{-\frac{1}{2}} z$, then the integrations reduce the expression to the form

$$q = 2\pi^{-\frac{1}{2}} \int_0^{u_1} e^{-u^2} du, \tag{11}$$

in which u_1 is the value of u when $z = A$. Replacing h_1 and h_2 in terms of r_1 and r_2 the limit u_1 is

$$u_1 = \frac{\rho a}{\sqrt{r_1^2 + r_2^2}} = \frac{\rho a}{r}, \tag{12}$$

and thus the probability of hit in azimuth is given by (11).

The integral in (11) is the well known probability integral of which tables are given in all works on the theory of errors. The most convenient table is that in which the values of the integral are tabulated for the argument $\frac{u_1}{\rho}$. Replacing u by t and u_1 by ρt_1 the integral may be written in the usual form

$$\varphi t_1 = 2\pi^{-\frac{1}{2}} \int_0^{\rho t_1} e^{-t^2} dt, \tag{13}$$

and the probability of hit in range may be expressed as

$$q = \varphi \frac{a}{\sqrt{r_1^2 + r_2^2}} = \varphi \frac{a}{r}, \tag{14}$$

which may be taken from the tables for any given values of a and r.

By the same reasoning the probability of hit in range is found to be given by

$$q' = \varphi \frac{A}{\sqrt{R_1^2 + R_2^2}} = \varphi \frac{A}{R}, \tag{15}$$

and finally the probability of hit on the area $4aA$ is,

$$Q = q\, q'. \tag{16}$$

Thus (14), (15), (16) are the practical formulas for use in finding by (13) the probability of hit on a rectangular target whose side in azimuth is $2a$ and whose side in range is $2A$. If a and A be made very small (14) and (15) reduce to the formulas deduced above for the small target. If r_2 and R_2 be made zero (14) and (15) become

$$q_1 = \varphi \frac{a}{r_1}, \qquad q'_1 = \varphi \frac{A}{R_1}, \tag{17}$$

which apply to the case where the aim is regarded as accurate.

INDEPENDENT FIRE.

The above formulas are for use in independent fire where several shot are fired from a single mortar, or where a volley is fired from several mortars of a battery, each mortar being independently aimed in azimuth and range with the intention of hitting the center of the deck of the ship. They will now be applied to the five groups of shots fired at Fort Monroe and Sandy Hook, the data for which are given in the report of the Board of army officers published in the *Journal of the United States Artillery* for May-June, 1897, Vol. VII, pp. 287-346. These data are stated in the following table, the resultant probable errors r and R_1 as also a column of means being added. The Roman numerals at the heads of the columns refer to the plates in the report upon which the distribution of the shots is shown. The probable errors are expressed in yards, and the deck of the *Royal Sovereign* which is the ship to be considered is taken as a rectangle 25 × 127 yards in size.

Table 1. *Data.*

	IV.	V.	VI.	VII.	VIII.	**Means.**
Mean range in yards	5957	6921	7764	9285	10754	8136
Probable error in azimuth $= r_1$ . . .	6.4	16.1	10.8	12.4	21.5	13.4
Probable error of azimuth finder $= r_2$	16.3	7.6	12.6	15.0	17.4	13.8
$r = \sqrt{r_1^2 + r_2^2}$	17.5	17.8	19.4	19.5	27.7	
Probable error in range $= R_1$ . . .	25.6	45.9	42.6	30.4	42.2	37.3
Probable error of range finder $= R_2$	78.5	139.0	195.6	161.	190.2	153.0
$R = \sqrt{R_1^2 + R_2^2}$	82.5	146.4	200.2	164.5	194.8	

The first case to be discussed is where the ship lies in a transverse position with respect to the line of fire. Here $a = 63.5$ and $A = 12.5$ yards. Dividing these by the above values of r_1 and R_1 the arguments are found for taking the probabilities from the integral table for (17) when the aim is regarded as accurate; dividing by r and R the arguments are found for use in (14) and (15) when the probable errors in aim are to be considered. In the above data the shots were fired with accurate aim and r_1 and R_1 were computed from the observed shot distribution, while r_2 and R_2 were determined by tests on the azimuth and range finders. In the following tabulation the probabilities are first given for this case of accurate aim, or when $r_2 = 0$ and $R_2 = 0$. The probabilities q_1 and q'_1 being found, the product of these is Q_1

which is the final probability of hit; these values of Q_1 multiplied by the actual number of shots give the probable number of hits to be expected, and this is compared with the number actually found to fall on the rectangle in the given position. For the case of aim such as would occur under ordinary conditions of warfare, where the probable errors r_2 and R_2 come into play, the probabilities are also found. A comparison of the values of Q_1 and Q for the two instances shows that the probable number of hits under ordinary aim is about one-third of those under accurate aim for the shorter ranges and about one-fifth for the longer ranges.

Table 2. Independent Fire.

Ship in Transverse Position.	IV.	V.	VI.	VII.	VIII.	Means.
Mean range in yards . . .	5957	6921	7764	9285	10754	8136
Accurate Aim.						
Azimuth probability $= q_1$.	0.9999	0.9921	0.9996	0.9993	0.9536	
Range probability $= q'_1$ . .	0.2580	0.1456	0.1567	0.2184	0.1582	
Probability of hit $= Q_1$ . .	0.2580	0.1444	0.1566	0.2182	0.1509	0.1856
Actual number of shots . .	8	8	11	5	10	
Probable number of hits . .	2.06	1.15	1.72	1.09	1.51	
Actual number of hits . .	2	2	0	1	1	
Ordinary Aim.						
Azimuth probability $= q$	0.9855	0.9838	0.9729	0.9722	0.8785	
Range probability $= q'$ . .	0.0817	0.0457	0.0334	0.0409	0.0344	
Probability of hit $= Q$ . . .	0.0805	0.0450	0.0324	0.0397	0.0302	0.0456

The ship will now be taken in the longitudinal position with respect to the plane of fire. Here $a = 12.5$ and $A = 63.5$ yards.

Table 3. Independent Fire.

Ship in Longitudinal Position.	IV.	V.	VI.	VII.	VIII.	Mean
Mean range in yards . . .	5957	6921	7764	9285	10754	813
Accurate Aim.						
Azimuth probability $= q_1$	0.8122	0.3993	0.5648	0.5034	0.3048	
Range probability $= q'_1$.	0.9056	0.6494	0.6851	0.8412	0.6899	
Probability of hit $= Q_1$ . .	0.7355	0.2593	0.3870	0.4235	0.2132	0.4
Actual number of shots . .	8	8	11	5	10	
Probable number of hits . .	5.88	2.07	4.26	2.12	2.13	
Actual number of hits . .	6	4	6	2	1	
Ordinary Aim.						
Azimuth probability $= q$	0.3698	0.3641	0.3365	0.3350	0.2395	
Range probability $= q'$ . .	0.3960	0.2305	0.1693	0.2052	0.1739	
Probability of hit $= Q$ . . .	0.1464	0.0839	0.0569	0.0687	0.0417	

Dividing these by r_1 and R_1 the arguments for accurate aim are found, and dividing by r and R the arguments for ordinary aim result. With these arguments the range and azimuth probabilities are taken from the integral table and the product of these gives the probability of hit on the deck. For the case of accurate aim the comparison is made as before with the probable and actual number of hits on the rectangle in the given position. The final values of Q for ordinary aim are seen to vary from one-sixth to one-third of those for accurate aim.

On comparing the probabilities of hit for the transverse position of the ship with those for the longitudinal position it is seen that the latter position is by far the most favorable, as its values of Q under ordinary conditions of fire are about twice as large for the shorter ranges and about fifty per cent larger for the longer ranges.

PARALLEL FIRE ON A SMALL TARGET.

By the term parallel fire is understood that method in which all the mortars of a battery are aimed parallel to an imaginary mortar at the center of the battery, this imaginary mortar being aimed in azimuth and range with the intention of hitting the middle of the deck of the ship. The typical mortar battery of the U. S. army consists of sixteen mortars arranged in four groups of four mortars, the center of each group being located at the corner of a rectangle. The size of this rectangle, as laid down on the plates of the report above cited, is 40 by 80 yards. If a line be drawn through the center of the rectangle parallel to its longer side, this line will be called the principal axis of the battery. The length of the longer side of the rectangle will be denoted by $2B$ and that of the shorter side by $2b$. The four mortars in each group are so near together that their distances apart need not be considered in the following discussion.

Let a volley be fired from the sixteen mortars upon a ship situated on the line of the principal axis of the battery, as in plates IV, V, VI, VII, VIII of the report. The two curves marked (2) on these plates are the probability curves of shot dispersion in azimuth while the curve marked 3 is the probability curve for the error of aim in azimuth. Using the same notation as before, the probability of hit in azimuth upon the small strip $2a$, for the error x in azimuth aim is

$$y_1 = \tfrac{1}{2}\pi^{-\frac{1}{2}} h_1 \left(e^{-h_1^2(x+b)^2} + e^{-h_1^2(x-b)^2}\right) \times 2a, \qquad (18)$$

and the probability that this error in azimuth aim exists is

$$y_2 = \pi^{-\frac{1}{2}} h_2 e^{-h_2^2 x^2} dx. \tag{19}$$

The product of these probabilities is

$$y = \pi^{-1} a h_1 h_2 e^{-h_1^2 b^2} e^{-(h_1^2 + h_2^2) x^2} (e^{2h_1^2 bx} + e^{-2h_1^2 bx}) dx, \tag{20}$$

and the integral of this between the limits $-\infty$ and $+\infty$ is the probability of hit in azimuth under the two circumstances of error in shot distribution and error in designated azimuth. This integral is

$$p = \frac{2a h_1 h_2}{\pi^{\frac{1}{2}} \sqrt{h_1^2 + h_2^2}} e^{-\frac{h_1^2 h_2^2 b^2}{h_1^2 + h_2^2}},$$

and replacing h_1 and h_2 by their values in terms of the probable errors r_1 and r_2, and letting r represent $\sqrt{r_1^2 + r_2^2}$, this reduces to

$$p = \frac{2\rho a}{\pi^{\frac{1}{2}} r} e^{-\frac{\rho^2 b^2}{r^2}}, \tag{21}$$

which is the probability of hit in azimuth upon the small target.

By an exactly similar process of reasoning the probability of hit in range for the small target is

$$p' = \frac{2\rho A}{\pi^{\frac{1}{2}} R} e^{-\frac{\rho^2 B^2}{R^2}}, \tag{22}$$

and the product of (21) and (22), or

$$P = pp'$$

is the probability of hit on the small rectangular target whose sides in azimuth and range have the lengths $2a$ and $2A$.

On comparing these probabilities p and p' for the parallel method with q and q' as given in (5) and (6) for the independent method, it is seen that

$$p = q e^{-\frac{\rho^2 b^2}{r^2}}, \quad p' = q' e^{-\frac{\rho^2 B^2}{R^2}}, \tag{23}$$

and therefore

$$P = Q e^{-\frac{\rho^2 a^2}{r^2} - \frac{\rho^2 A^2}{R^2}}, \tag{24}$$

or the probability of hit on a small target by the parallel method is always less than by the independent method if b, B, r, R have finite values. When $b = 0$ and $B = 0$ all the mortars are located in one spot and then P becomes equal to Q. When $r_2 = \infty$ and $R_2 = \infty$, the shots are fired at random without aim of any kind; then r and R are infinite and P becomes equal to Q.

PARALLEL FIRE ON A LARGE TARGET.

By an analogous process the probability of hit for a target of any size, when placed on the line of the principal axis of the battery, may be deduced. Let z be any distance in azimuth from the middle of the target, then the probability of hit in azimuth on the strip dz, when the error x occurs in azimuth aim, is

$$y_1 = \tfrac{1}{2}\,\pi^{-\frac{1}{2}}\,h_1\left(e^{-h_1^2(x+b+z)^2} + e^{-h_1^2(x-b+z)^2}\right)dz. \qquad (25)$$

Multiplying this by the probability of the occurence of the error x, as given by (19) the probability y of hit in azimuth on the strip dz is found for both shot dispersion and inaccurate aim. Then this expression is to be integrated with respect to x between the limits $-\infty$ and $+\infty$, and with respect to z between the limits $-a$ and $+a$. The result of these integrations is

$$p = \pi^{-\frac{1}{2}}\int_{\rho t_2}^{\rho t_1} e^{-t^2}\,dt, \qquad t_1 = \frac{b+a}{r}, \qquad t_2 = \frac{b-a}{r}. \qquad (26)$$

The value of p is hence one-half of the probability integral φt between the given limits. The integral table may be readily employed for finding numerical values by using first the argument t_1 and secondly the argument t_2, and taking one-half of the difference of the corresponding tabular values. In general discussions the second limit may be reversed in sign and the two values ot φt be added, thus

$$p = \tfrac{1}{2}\left(\varphi\,\frac{a+b}{r} + \varphi\,\frac{a-b}{r}\right) \qquad (27)$$

is the probability of hit in azimuth for the target whose length in azimuth is a, when the center of the target is on the line of the principal axis of the battery.

In a similar manner the probability of hit in range is found to be expressed by

$$p' = \tfrac{1}{2}\left(\varphi\,\frac{A+B}{R} + \varphi\,\frac{A-B}{R}\right), \qquad (28)$$

and finally the probability of hit for the rectangle is

$$P = pp', \qquad (29)$$

and if this be multiplied by the number of shots the probable number of hits under ordinary conditions of aim is obtained.

By comparing (27) and (28) for the parallel method with (14) and (15) for the independent method, it is seen that p is less than q, and p' less than q'; for the maximum values of (27) and (28) occur when $b = 0$ and $B = 0$, and only under this condition can they become as great as (14) and (15). It may also be shown that if a and A are very small, (27) and (28) will reduce to (21) and (22) previously established for the small target.

SHIP ON LINE OF PRINCIPAL AXIS.

The probabilities p, p', P, will now be computed for a ship whose center is on the principal axis of the battery. The dimensions to be used for the battery rectangle are 40 × 80 yards, so that $b = 20$ and $B = 40$ yards. The size of the ship is as before taken to be 25 × 127 yards, and a volley is fired upon it from all the mortars of the battery, each mortar being pointed by the parallel method.

When the ship is in the transverse position with respect to the principal axis and the plane of fire, $a = 63.5$ and $A = 12.5$ yards; thus (27) and (28) become

$$p = \tfrac{1}{2}\left(\varphi\,\frac{83.5}{r} + \varphi\,\frac{43.5}{r}\right), \qquad p' = \tfrac{1}{2}\left(\varphi\,\frac{52.5}{R} - \varphi\,\frac{27.5}{R}\right).$$

When the ship is in the longitudinal position, $a = 12.5$ and $A = 63.5$ yards, and (27) and (28) take the form

$$p = \tfrac{1}{2}\left(\varphi\,\frac{32.5}{r} - \varphi\,\frac{7.5}{r}\right), \qquad p' = \tfrac{1}{2}\left(\varphi\,\frac{103.5}{R} + \frac{23.5}{R}\right).$$

The values of r and R are given in Table 1; from these the various arguments are computed and then the corresponding values taken from the probability integral tables. Performing the operations indicated, the values of p and p' for each case are found, and then $P = pp'$ is the probability of hit. The following tabulation gives these probabilities for the two positions of the ship. For the transverse position the values of P are divided into the values of Q given in Table 2, and the ratios indicate the superiority of the independent method with respect to probable number of hits. For the longitudinal position the values of P

Table 4. *Parallel Fire.*

Ship on Principal Axis of Battery.	IV.	V.	VI.	VII.	VIII.	Means.
Mean range in yards . . .	5957	6921	7764	9285	10754	8136
Transverse Position.						
Azimuth probability $= p$.	0.9523	0.9496	0.9332	0.9323	0.8348	
Range probability $= p'$.	0.0771	0.0452	0.0334	0.0404	0.0344	
Probability of hit $= P$ . . .	0.0735	0.0429	0.0311	0.0376	0.0287	0.0428
Patio of Q to P	1.095	1.047	1.018	1.056	1.055	1.054
Longitudinal Position.						
Azimuth probability $= p$.	0.2814	0.2856	0.26870	0.2654	0.2221	
Range probability $= p'$.	0.3734	0.2265	0.1650	0.2025	0.1724	
Probability of hit $= P$ . . .	0.1050	0.0647	0.0443	0.0538	0.0383	0.0612
Ratio of Q to P	1.394	1.298	1.287	1.279	1.088	1.269

are divided into the values of Q given in Table 3, and the ratios show the advantage of the independent method. The means give 5.4 and 26.9 per cent. advantage for the two cases, or about 16.2 per cent. as a rough average for all positions within the given limits of range.

SHIP HAVING AZIMUTH OF 45° WITH PRINCIPAL AXIS.

With the independent method of firing the probability of hit is the same whatever be the azimuth of the ship with respect to the principal axis of the battery. With the parallel method, however, the probability is different for different azimuths. The forgoing principles and formulas may be applied to the computation of the probabilities $p, p', P,$ for a ship in any position. Let a line be drawn from the center of the battery to the center of the ship, and let θ denote the angle which this line makes with the principal axis. Let the four corners of the battery rectangle be projected on this line and on a direction normal to it. Two corners will then be apart a distance $2b_1$ in azimuth and $2B_1$ in range, while the other two corners will be apart $2b_2$ in azimuth and $2B_2$ in range. The values of these are expressed in terms of b and B as follows:

$$\left.\begin{array}{ll} b_1 = B\sin\theta - b\cos\theta, & b_2 = B\sin\theta + b\cos\theta, \\ B_1 = B\cos\theta + b\sin\theta, & B_2 = B\cos\theta - b\sin\theta, \end{array}\right\} \quad (30)$$

For the case where $\theta = 45$ degrees, $b = 20$ and $B = 40$ yards; these reduce to the values $b_1 = 14.14$, $b_1 = 42.43$, $B_1 = 42.43$, $B_2 = 14.14$ yards.

The probability of hit in azimuth by a volley fired from the four corners may be written by extending the theorem (27), namely,

$$p = \tfrac{1}{4}\left(\varphi\frac{a+b_1}{r} + \varphi\frac{a-b_1}{r} + \varphi\frac{a+b_2}{r} + \varphi\frac{a-b_2}{r}\right), \quad (31)$$

and the probability of hit in range is, by a similar extension of formula (28),

$$p' = \tfrac{1}{4}\left(\varphi\frac{A+B_1}{R} + \varphi\frac{A-B_1}{R} + \varphi\frac{A+B_2}{R} + \varphi\frac{A-B_2}{R}\right), \quad (32)$$

and the final probability of hit on the deck is $P = pp'$.

When the ship is in a transverse position with respect to the plane of fire $a = 63.5$ and $A = 12.5$ yards, and then using the values of r and R given in Table 1, the arguments are found for computing (31) with the help of the integral table. When the ship is in the longitudinal position $a = 12.5$ and $A = 63.5$ yards, and using the same values of r and R the second set of arguments is deduced. The functions being added or subtracted as (31) and (32) indicate, the probabilities p and p' are found, and lastly the probabilities of hit P are computed. The following table gives the results of these computations, and also the ratios of Q to P for the two positions. When the ship is in the transverse position the advantage of the independent over the parallel method is on the average 14.2 per cent.; when it is in the longitudinal position the mean advantage is 60.2 per cent. For the former case the advantage of the independent method is not related to length of range; for the latter case it increases as the range decreases.

Table 5. Parallel Fire.

Ship on Line making Angle of 45° with principal Axis of Battery.	IV.	V.	VI.	VII.	VIII.	Means.
Mean range in yards . . .	5957	6921	7764	9285	10754	8136
Transverse Position.						
Azimuth probability $= p$	0.8808	0.8775	0.8608	0.8592	0.7512	
Range probability $= p'$ . .	0.0786	0.0453	0.0334	0.0406	0.0344	
Probability of hit $= P$ . .	0.0630	0.0397	0.0289	0.0349	0.0259	0.0385
Ratio of Q to P	1.162	1.113	1.127	1.138	1.170	1.142
Longitudinal Position.						
Azimuth probability $= p$	0.2148	0.2143	0.2106	0.2103	0.1843	
Range probability $= p'$ . .	0.3844	0.2277	0.1684	0.2037	0.1726	
Probability of hit $= P$ . . .	0.0826	0.0488	0.0355	0.0483	0.0319	0.0494
Ratio of Q to P	1.774	1.720	1.606	1.604	1.307	1.602

CONCLUSION.

The formulas deduced above for the probability of hit when the probable error is known show that the square of this added to the square of the probable error of shot dispersion gives the square of the resultant probable error to be used in the computations. The data in Table 1 and the results in Tables 2 and 3 show that the ordinary inaccuracy in aim in mortar fire is a factor causing great waste in shots, and hence every effort should be made to reduce this to a minimum. If inaccuracy in aim could be wholly avoided the probable number of hits under independent fire would be about four times as great as at present. For parallel fire no computations on accurate aim have been made because in this case the parallel method is at its greatest relative disadvantage, as formula (24) clearly shows.

The formulas deduced for the probability of hit under parallel fire demonstrate this to be always less than for the independent method. The results of the computations for ordinary aim which are recorded in Tables 4 and 5, show that the average superiority of the independent method is about 16 per cent when the ship is on the principal axis of the battery and about 37 per cent when it has an azimuth of forty-five degrees with respect to the principal axis. In the long run, then it has about 25 per cent advantage; that is, the average probable number of hits by the parallel method is only about four-fifths of the average probable number of hits when all the mortars of the battery are fired by the independent method.

A REPLY TO THE REPORT OF A BOARD ON SEA-COAST MORTAR FIRE.

BY J. T. HONEYCUTT, FIRST LIEUTENANT, FIRST ARTILLERY.

In the May—June 1897 Number of the *Artillery Journal* is printed "by permission of the Major-General, Commanding the Army," the Report of a Board "Convened by the Commanding Officer, U. S. Artillery School, to consider and report upon a paper by 1st Lieutenant John T. Honeycutt, 1st Artillery."

The subject of the paper referred to was "Parallel and independent fire, with special reference to mortar batteries."

The paper referred to stated: "The demonstration given below was prepared more than four years ago, being intended to supplement a different one of the same general principle, which latter demonstration, though never disproved, had been officially discredited by high authority.

"The demonstration here given I sent at the time to Professor Merriman of Lehigh University, author of a standard work on probabilities, and one of the foremost mathematicians of the country, requesting him to make a careful examinations of it, and inform me of his opinion as to its soundness. This he did and pronounced it to be correct.

The adverse opinion which I then held, and expressed, in reference to the proposed method of firing, and to the form of mortar battery which seemed to have been founded on this method of firing as its corner-stone, I have never seen any sufficient reason for changing; although I fully recognize that the defects of the system were greatly exaggerated in the paper referred to."

Further on the paper stated: "The "probable number of hits" and "the probability of at least one hit" are two distinct mathematical questions, and it is only the first of these two questions that my demonstration, the one referred to above and the one given below, deal with."

The conclusion drawn from my demonstration was expressed in italics as follows: "*The probable number of hits from a battery of mortars will be greater if the mortars are aimed independently at the target than would be the case were the mortars aimed by the parallel method.*"

My proposition was stated mathematically by the inequalily:

$$Q^1 + Q^2 + Q^3 + \dots Q^{16} > P^1 + P^2 + \dots P^{16}$$

in which Q^1 &c., represented the probabilities of hitting by the individual mortars when aimed by the independent method; and P^1 &c., the same by the parallel method.

Conclusion 10 of the Report of the Board reads:

"10. The application of these principles to Lieutenant Honeycutt's proposition shows that the expression $Q^1 + Q^2 + \dots > P^1 + P^2 + \dots$ is not generally true, and that the relation between Q and P depends upon circumstances."

And referring to a table in which the results of the investigations of the Board are summarized, page 344, the report reads:

"The table is based on the assumption that the designated position of the target and the center of impact coincide,—the most favorable case for the independent method. Column 5 shows that even under this most favorable supposition the independent method will be inferior in probable number of hits to the typical parallel method, in 6.72 cases out of 7.72."

After learning what the Report was, by seeing it in the *Journal*, and thoroughly believing my proposition to be absolutely true, I sent copies of the *Journal* to a number of gentlemen of high authority on the subject of probabilities, and asked for their views on the Report. Among others I sent copies to Professor Merriman of Lehigh University, and Prof. Johnson of the Naval Academy, who are authors of standard works on probabilities, and who were recommended to me by the Secretary of the American Mathematical Society as being of the highest authority, the other two recommended being Prof. Simon Newcomb, and Prof. Woodward of Columbia University. The latter two have informed me that they could not give the necessary time to the subject.

Professor Merriman writes: "I find no occasion to change my opinioh regarding the correctness of your paper," and, after a critical survey of the Report: "It is thus seen that the Board has deduced nothing which reflects upon your proposition proving that the probable number of hits by a volley from the independent battery is greater than that by a volley from the parallel battery."

Professor Johnson writes: "I have not been able to give such a study to the subject as would enable me to criticise the Report's conclusions, except as to your actual proposition as stated, in which you are clearly right. . . . ΣQ is the maximum of ΣP, because Q is the maximum of P. * * * Thus the Board by adopting your notation put themselves in the position of maintaining a proposition 'simply absurd' as you say." The quotation "simply absurd" was from a short type-written paper I had prepared in reply to the Report.

The eminent astronomer and mathematician, Professor Holden of the Lick Observatory writes: "As I understand the case your method is entirely correct. It is also entirely general and your conclusion (in italics at the foot of page 289) is established mathematically."

Lieutenant Harlow, 1st Artillery writes: "I have been over the article on mortar firing in the *Journal* and believe fully that your proposition as I understand it, viz.: that the independent method will *in the long run* give the greater number of hits, is mathematically true."

In view of the weight of authority given above, I offer no further argument in support of my proposition as stated.

The Report would seem to indicate that the Board had in mind the "probability of at least one hit in a volley," though the Report nowhere says so.

The figures of the Report do not give in any case the relative "probability of at least one hit" but the ralative "probable number of hits" *if*, the ship is in a certain position with respect to the center of impact. This *if* as one of my high authorities wrote me, does not belong to a case of *a priori* probability. We do not know before firing what the position of the ship will be with respect to the center of impact. In firing a single shot the probability that the ship in any one position will be hit is, as the same authority writes me, the product of the probability that the shot will strike in that location multiplied by the probability that the ship will be there. This latter probability is indicated in the Report by the ordinates of the range-finder curves. The Board nowhere multiplied by this factor. Consequently the Report gives just as much weight to a probable hit within a rectangle equal to the deck of the ship at a long distance from the center of impact as to a probable hit within such rectangle at or near center of impact. This could be justified only under the supposition that the ship is no more likely to occupy the position of the rectangle at or near center of impact than it is to occupy a rectangle remote from this center. This is equivalent to supposing that there is no accuracy at all, but that the firing is entirely at random; in which latter case the range-finder (or accuracy) curve becomes a straight line; and the ordinates, our accuracy factors, become all equal.

In all the tables accompanying the plates the numbers should have been multiplied by the corresponding ordinates of the range-finder curve; since the probability of hitting the ship in any position is equal to the probability of the shot's falling in that position multiplied by the probability of the ship's being in that position.

Also, since the aim of the Board was, as it appears, to show the relative probabilities of "at least one hit in a volley" for the two batteries, there should have been made further computations to show in each case the probability of "at least one hit."

Failing to do this the Board had no figures from which to draw conclusions either as to the "probable number of hits" or the "probability of at least one hit."

Any two corresponding columns of the tables in the Report if carried out to infinity, will when added up give equal sums, since the areas of the curves are equal, each containing all the errors. But after we have multiplied through by the ordinates of the range-finder curve, the Q columns give the greater sums because the larger numbers at the heads of the columns would be multiplied by the larger range-finder ordinates, thus proving at once my proposition of the greater "probable number of hits" to be in favor of the independent battery.

We will now give some special consideration to the subject of the probability of "at least one hit in a volley." We should not sacrifice every other consideration to this one. To do that would be equivalent to acting under the supposition that one hit is as good as two or more, or that a single hit will always disable the ship. Even though this "at least one hit" should be our main object, the Board has failed to bear in mind an evident truth; namely that while to get the best effect, some scattering of the projectiles is necessary, there is a limit beyond which the effect ceases to increase and begins to decrease. For example if there are left at and near the center of impact vacant spaces larger than the deck of the ship, it is evident that the scattering has become too great. We would then be leaving places of safety for the ship near the center of impact for the sake of a possible hit in a position more remote from the center, where there is a smaller probability of the ship's being than there is of its being at the center, however small the probability in the latter case may be.

This is analogous to the case of the shot-gun. Up to a certain degree the effect of scattering increases with its extent, but it may become too great even for the very poor marksman.

By substituting in the probability integral successive values for the probable error in range, I have learned that if this probable error be as great as 110 yards there will be for the range zone extending 12½ yards on each side of the center of impact a probable number of hits less than one. This shows that with the scattering corresponding to this error in range we are leaving vacant spaces at and near the center greater than the width of the target, and therefore that for the lateral position of ship we have passed beyond the limit of maximum advantage of scattering, however great the inaccuracy of aim may be. I have selected this case of extreme inaccuracy merely for convenience to make sure of getting a case where the scattering is too great, which case I wish to use for a purpose made evident further on. With anything like a reasonable degree of accuracy this limit would of course have been far smaller. With perfect accuracy we would require no scattering, and as we pass from perfect accuracy to the greatest inaccuracy, so long as the firing is not at random, we should for a target 25 yards wide increase our scatterihg from that determined by the probable error 0 in range to that determined by the probable error 110 yards.

We at least know then that for all cases of probable error as great as 110 yards the independent method would for the lateral position of ship give a greater probability of "at least one hit" than the parallel method, since the latter method gives the greater scattering. Yet in all these cases the probability curves would, as in the cases of the groups of shot treated in the Report, intersect at some distance from the vertical axis. From the center of impact to the foot of the ordinate of intersection of the curves there would be for all positions of the ship a superiority on the side of the independent method, and for all positions of the ship beyond this point, extending indefinitely, or at least as far as there is any possibility of a shot's going, the superiority would be on the side of the parallel method. Therefore the method of reasoning employed in the Report would here, as well as in the cases dealt with, show a superiority for the parallel method, the probability of the ship's being between center of impact and the point determined by the intersection of the curves being very small, and the inaccuracy being great at the long range necessary to produce so great a shot dispersion.

We see then that the method employed by the Board would lead to a result which is known to be wrong in this case. The method therefore cannot be a correct one.

So far as the Report shows, the average case cited on page 344 in the Summary may be a case where the advantage with reference to probability of "at least one hit" is on the side of the independent system. The statement there made, however, that the parallel would be superior in 672 cases out of 772 would still be true in the sense in which the Board must have meant it, that is, in the sense of 672 positions of the ship out of 772, although the independent method might give the greater general probability of "at least one hit." This apparant inconsistency is explained by the fact that the superiority of the independent system in the 100 positions of the ship may be great enough to more than offset the superiority of the system in the other 672 positions of the ship. The statement made in the Summary of the Report is in the sense explained, always true; but at the same time the general superiority may be on the side of the independent method. The language of the Summary is therefore very misleading to the casual reader. To one who has carefully analyzed and understands it, it has no pertinent meaning; and in fact means nothing more than that the parallel method scatters the shot more widely than the independent method; an assumption with which the Report starts out.

Since, according to the Report, our inaccuracy of fire is to result so largely from the inaccuracy of the officially adopted range-finder, that is a subject requiring very serious consideration. It is a serious question as to whether we should rely on a system which at the long ranges is so inaccurate as represented in the Report.

If we are to use so inaccurate a system we should not rely on one range-finder to fire all our mortars by, but should have several. By a well known and simple principle of probabilities the chances of at least one range-finder being correct where several are used independently is much greater than the probability that any one will be correct. If therefore we fired our four groups of mortars each with a range determined by its own range-finder operated independently of the others, we would increase our chances of firing at least one group with a correct range and azimuth, and therefore increase our chances of hitting the ship.

If the columns of figures in the Report be compared, it will be found that in no case, except that of the first group, is the number of shot "wasted" (by more than one shot striking in a rectangle the size of the ship's deck) much greater for the independent than for the parallel system; and by comparing the different tables it will be seen that the greater the probable error the less this difference becomes. In no case is this 'waste' so great as in the case of the experimental firing at Sandy Hook, as shown in the plates accompanying the article by the author of the typical battery in the May—June 1896 number of the *Artillery Journal.*

At the 3000 yards range 7 shot fell within a space less than the deck of the Royal Sovereign, located with center about 40 yards from the center of impact and having her longer axis nearly parallel to the shorter axis of the battery. Four fell in another equal space at about the same distance in an opposite direction from the center.

At the 6000 yards range 6 shot struck within a space equal to the ship's deck for one position, and five for another position, both positions at a considerable distance from the center of impact.

For both ranges it will be seen from the diagrams that the ship could pass clear across the field in a direction nearly at right angles to the larger axis of the battery and close by the center, and have room to spare, without being touched by a shot.

Economy of shot and regularity of dispersion is not therefore shown in this, the only experimental firing we have had from which to draw conclusions in this connection.

In no case do the columns of figures in the Report make it evident that there is a greater probability of "at least one hit" by the parallel method than by the independent, unless it be in the case of the first group. On the contrary these figures in the table for the second group indicate clearly that for longitudinal position of ship this probability would be greater for the independent system, since the numbers in columns 16 are greater than the corresponding numbers in 17, and those in column 18 greater than those in 19, down as far as opposite 110 in column 1, or for a distance of 110 yards from the center of impact. This 110 yards from center of impact includes as much as 88 per cent of the shots of the independent system and 85 per cent of those of the typical battery. It is then, I think, evident that in this case also, the independent system has the advantage both with reference to "probable number" and "probability of at least one."

We know that when the probable shot error is large, and also when the inaccuracy of aim is not great, we have too great scattering without resorting to artificial means by the form of the battery and parallel fire.

On the whole I think we are justified in concluding that at the effective mortar ranges we have sufficient scattering unavoidable, and that we would get the better effect by aiming the mortars independently at the target. This is equivalent to saying that if parallel fire is to be used it should be from mortars brought as near together as practicable. When this is the case the two systems become practically one, and for the sake of convenience it would be wise to aim them parallel.

Certainly there has been nothing approximating to proof, either experimental or by mathematical investigation, that at the long ranges the effect of mortar fire would be increased by the form of the typical battery, using with it the parallel method of aiming.

I propose the following method for getting the relative probabilities of "at least one hit" by the two systems: Let Q_1 be successively the probability that a shot from one mortar of the independent battery will fall in range zones the width of target in range direction; q_1 the same in azimuth. Then $Q_1 q_1$ is the probability that the shot will fall in retangle the size of target; and $1-(1-Q_1 q_1)^{16}$ is the probability of at least one hit in the rectangle, and when multiplied by the ordinates of the two accuracy (or range-finder) curves gives probability that ship will be be in that rectangle.

For typical battery we have for probability that "at least one shot" will fall in above retangle the expression

$$1-(1-P_1p_1)^4\ (1-P_1p_2)^4\ (1-P_2p_1)^4\ (1-P_2p_2)^4$$
$$=1-[(1-P_1p_1)\ (1-P_1p_2)\ (1-P_2p_1)\ (1-P_2p_2)]^4$$

in which P_1 is range probability for the two front groups and P_2 the same for the two rear groups; p_1 is azimuth probability for the two right groups and p_2 the same for the two left groups. We must then as before multiply by the ordinates of range-finder (or accuracy) curve.

By applying these methods to a sufficiently large number of rectangles, we may from the respective sums of the results obtain the relative probabilities desired.

CONCLUSIONS.

1. The Report of the Board of Officers contains nothing that shows in any case either the "probable number of hits" or the "probability of at least one hit in a volley," for either the typical or the independent battery; and therefore there is nothing in the mathematical work of the Board to justify any conclusions as to the relative merits of the two systems.

2. The "Summary" of the Report given on page 344 is true from the point of view of the Report; but the method there employed would show that, from that point of view, the typical battery would in all cases be the superior even in cases where it has been shown that the independent battery would give both the greater ,, probable number of hits" and the greater "probability of at least one hit" in a volley. This "Summary" is therefore very misleading to the casual reader; and to one who has analyzed it and fully understands it, it has no pertinent meaning whatever.

3. My original proposition, given in italics at the bottom of page 289, is mathematically true, and the demonstration given established that proposition; namely, that the *independent method gives the greater probable number of hits*, which is the same as saying that *in the long run it will give the greater number of hits.*

4. For reasons of simplicity, or convenience, it is not objectionable, but advantageous, to use parallel fire from groups of mortars where these mortars are in close proximity to each other, as for example in the small groups of four in the typical battery.

5. No method of range-finding has yet been officially adopted which is sufficiently accurate for long ranges, such as are required for effective fire.

6. With such inaccuracy of range-finding as that represented in the Report, it would be unwise (if it could be avoided), to fire a large number of mortars depending for range on a single range-finder. The probability of hitting the ship would be very greatly increased by having a range-finder for each four groups of mortars, and firing each group with the range determined by its own range-finder; or we might use for all the mortars the mean of the several range-finder readings.

7. From the point of view of the artillerist no justification of the typical mortar battery has ever been established either by means of experimental firing or by mathematical investigation.

SEPTEMBER 7, 1897.

THE THEORETICAL AND PRACTICAL TRAINING OF THE LIGHT ARTILLERY GUNNER.

[Essay read before the Officers' (Artillery) Lyceum, Presidio, California, March 5, 1897].

The part to be played by Light Artillery in battle is universally acknowledged to be a most important one. The day was, and not so far distant, when field artillery held but an auxiliary status. The relative superiority of this arm over infantry, under modern conditions and within the first zone of fire action, has made it the principal arm throughout that zone; it is therein accorded first consideration in the choice of position. It there performs, independently, a most responsible task. Only when the inner limit of this outer field is traversed does it subordinate its movements to the infantry, while at the same time rendering indispensable assistance.

Considering the vital function to be performed by the field artillery, in view of its stride forward of late years in material development, it is somewhat surprising that corresponding attention, comparatively speaking, has not been given to its comprehensive and systematic training, particularly along subordinate lines. The thoughts and study of artillery officers seem to have been devoted chiefly to the seacoast or heavy artillery, with its more numerous technicalities, and perhaps greater complexities attending its growth and service. Keeping pace with the development of harbor defense and the consideration of the general duty of this branch of the line, the training of its personnel, the value and necessity of the same, have received a proportionate share of recognition,—throughout the arm and by the highest authorities of the army. Special reference is made to the personnel, as it is with the individual soldier, or a class of individual soldiers, that this discussion has to deal.

Carbaugh's book, Cronkhite's work, Ingall's Hand-book, Chester's Ballistics, and some other publications, while intended for non-commissioned officers, find their more natural application in the hands of the heavy artilleryman; they do not satisfactorily, if at all, cover or touch the ground for the light artillery gunner.

There is no book specially prepared for the latter that I know of.

Dyer's hand-book does not meet the need of the field gunner in the premises; he is virtually without guide. The Drill Regulations for light artillery are silent on the subject of the efficient training of the gunners. Various injunctions and numerous general rules are laid down under the heading "Artillery in the Field", but they, however, are too sweeping in their nature and scope.

For our gunner a start must be made nearer the beginning; his feet must have stepped on the first round of the ladder before he essays to grasp the top one. For example, he is provided with a sight, but his drill book nowhere tells him how to use it; among his enumerated duties is "pointing," but he is not told how to lay his gun. I am not here laying stress on the desirability of a book for the sake of a book; certainly there is such a thing as too much book learning. I believe the best way to teach men is orally, and practically by object lessons. Rather am I seeking to point out the comparative want of attention given our gunner, and the need of at least some few simple, clear instructions pertaining to his all important duty—gun laying.

Again, in another direction, we find the light artillery gunner and his training overlooked. A sharpshooter's badge, a marksman's pin, a sea-coast artillery gunner's insignia,—these are small things in themselves, but they mean far more than is read on their faces.

They are distinguishing marks and stamp the wearers as having received training, aud as having been judged, upon examination, efficient in their several grades. Is the light artillery gunner so much less useful as a public servant, is his function of such diminished significance that it is unnecessary to arouse *his* ambition or to stimulate *his* pride? By virtue of regulations from so high a source as the Headquarters of the Army, the heavy artilleryman is afforded annually an opportunity to exhibit his special fitness and proficiency as a gunner, and if deemed qualified is entitled to a decoration and the further distinction of having the fact noted on the muster rolls.

The skill of the infantryman and cavalryman is tested practically on the firing range.

Of the men of the line the light artillery gunner is the only one seemingly forgotten in the awards for excellence. In the interests of the service let us hope his day will come, and perhaps it will when the material status of his arm is more definitely settled. Field artillery has been for several years, and in some particulars is now, passing through a period or stage of transition.

Our present field gun is, it is believed, one of the best of its class, but it may soon give way to the *quick firer.* Recent unauthentic reports tells us that Germany will shortly equip her field artillery with the quick firing guns. Our shrapnel and time fuze must yet stand the practical test of service. Smokeless powder is knocking at the door for recognition and adoption. The field gun sight is surely susceptible of improvement. With these matters fixed satisfactorily, let the question of properly qualifying gunners be made a pronounced step on the road of progress, if its consideration must be delayed.

In the due recognition of the light artillery gunner let us not be misunderstood. It is not the medal or the badge that is so much desired, rather the salutary effect of this bestowal, in exciting increased interest, encouraging men to better equip themselves for their duties, developing the training and efficiency of the personnel;—in fine, *qualifying* gunners.

That there is wanting in our service specific instructions for the training of the gunners of the field artillery in their destinctive duties is patent. Even in the matter of the field artillery equipment no well defined rules are laid down as is the case with the infantry and cavalry. Regarding training, I am reliably informed that at our service school for light artillery no regularly prescribed course is followed, the details and methods being left to the several battery commanders. Satisfactory reasons for these wants may exist, but they are not readily discernible. I have seen the statement in a recognized military journal that all the principal nations of the world have an authorized system of artillery fire regulations, which cover the ground of the training of the personnel for field work. Individual battery instruction may work well under some circumstances, but uniformity and regularity, so much to be desired under modern tactical conditions, will not result therefrom. Sight must not be lost of that tactical principle governing field artillery which predicates its employment upon concentration, chiefly by battalions, at least not upon individual battery maneuver and action; the latter is the exception, and that exception is enunciated in paragraph 1002, Drill Regulations.

THE IMPORTANCE OF THE OFFICE AND THE RESPONSIBILITY OF THE GUNNER.

A battery in action (and all training should be thus single-purposed) is a machine; the battery commander, by his will, sets it in motion, stops it, makes it work slowly or rapidly." A whole is composed of its parts; its integrity varies as do the elements that go to make it up. All-round efficiency is assured only when each individual factor is in good running order, and when each part smoothly performs its share of the work. The more evenly each man executes his special function, the more perfectly does the machine operate. The true role of the gun is to "hit," but the means to this end is the proper laying of the piece. This must be done with *accuracy*, *regularity* and *uniformity*, and with light artillery *celerity* of action is of great moment. The battery commander is charged with the réglage or regulation of the fire, and, technically speaking, he may "*control*" it under certain conditions (*vide* Drill Regulations). He orders the kind of projectile to be used; he determines the proper elevation and fuze; he *directs*, but another executes. A railroad conductor directs and controls his train, orders starts and stops, but the hand that holds the throttle has a very large responsibility in its running. Similarly, the gunner holds the key to a situation, and by its fit or misfit he opens the door to effective or ineffective fire.

The gunner behind the breech is the captain's executive; while he neither regulates nor controls the fire, he has a vital share in its delivery. A mistake in setting the sight, an error in correcting for reported observations, a misinterpretation of the target indicated; these result in so much loss. How essential then that the gunner be thoroughly trained! But the captain is virtually in the air without reliable observations of fire; he is dependent upon trained observers, unless he performs such duty himself. Indeed the observer is as important, if not more so, than the man who corrects the sight and cuts the fuze. It is evident that we are dealing with an office or individual of responsibility.

But to come more directly to the subject of the discussion: the training of the light artillery gunner. The first question which presents itself is, what should be his instruction; in what direction is his training to be applied? Will the scheme for the instruction and examination of the sea-coast gunner afford us any light? It may be of some profit to inquire. This scheme or schedule is published in General Orders, No. 41, Headquarters of the Army, 1896. It comprises ten sub-heads or "minimum qualifications," which for our special purpose may be classified into five general divisions, as follows:

Service.—Subhead 3: Service of the various siege and seacoast pieces, etc.

Mechanical maneuvers.—Sub-head 10: Cordage, blocks and tackle, etc.

Range tables.—Sub-head 9: Use of Range Tables.

Observation.—Sub-heads 1, 2, 4, 5, 6 and 7: Use of angle measuring instruments; plotting board; judging distances to stationary and moving objects; judging speed of vessels and velocity of wind.

Gun laying.—Sub-head 8: Laying guns, including allowances for wind, drift, and speed of targets.

And, for gunnery specialists, there are added:

a. Telegraphy and signalling.

b. The practical care and maintenance of simple batteries, etc. Also, the use of Meteorological Instruments and Range Table work.

The work to be performed by light artillery differs so markedly in character from that of the sea-coast arm that it will, of course, be necessary to eliminate several features of this schedule, which are not applicable or desirable in the training of the individual before us. Let us in a few brief words apply the knife.

One general thought, however, before doing so. The light artillery gunner must, perforce, be practical; herein lies his skill.

His round of work may be a science, but he need not be scientific, nor does he need to solve ballistic problems, nor delve into the niceties of gunnery. His unaided eye is his observing instrument; his good judgment and skill, his plotting board and graphic table of fire. For observing and determining deviations and for calculating gun data, the stationary gunner *can* call to his assistance various devices, apparatus, and "ometers." The field gunner must and does arrive at results by a quick road and a short cut.

Service of the piece.—The gunner must, of course, know the service of his piece, but he acquires this familiarity in his capacity as cannoneer.

Mechanical maneuvers.—Likewise, his mechanical maneuvers are performed by him in the same role, and his prolonge constitutes practically his "cordage, block and tackle."

Use of Range Tables.—I believe that for the light artillery gunner the range table is essentially the *means* to an end, but not that end itself. Absolute reliance cannot always be placed on it, however accurately calculated. We must not overlook the fact of certain variable factors which influence its use. The performance of the powder is ever varying, owing to climatic and atmospheric conditions, to variations in its nature, age, and the amount of shaking up it gets in the limber. Moreover, the "jump" is much affected by the character of the ground. The initial velocity, practically speaking, is an "unknown quantity and a variable." "Lieutenant Whistler is the only range table writer who seems to have appreciated the importance of this point. He prescribes a method for obtaining the initial velocity for the day. No gunner of experience will willingly believe that initial velocity for the forenoon will be the same for the afternoon." All firing is, in a measure, guess work, and the best gunner is he who can, by the exercise of his judgment, and almost instinctively, make the closest approximation. The range table serves a most useful purpose, however. It is of course necessary in the preliminary training as a reference and a guide, and for the further object of familiarizing the gunner, as much as possible, with its essential figures. Study and practice with it ought to enable the officers, if not every one of the gunners, to remember the elevation and fuze data for the round numbers of the table, and to readily make necessary interpolations.

It is believed that there will be little use for other figures in action. I would have the gunner use the table with this idea in mind, rather than teach him, solely, that he is dependent upon it and that he must always consult it. Further, time is an important consideration with field artillery fire; whatever is sought to be accomplished must be done quickly. In the inability of the gunner to promptly and accurately make corrections rests his practical efficiency.

Observation.—For very obvious reasons, the field gunner is denied the use of instruments for observing and determining deviations, and for working up gun data. But in lieu of these aids he depends upon instruments purely personal and controlled by his personal equation. Experience is his best assistant; by practice alone can he acquire it surely. In laying, the field gunner works with an *absolute* deviation; he is not disturbed by its components.

A shot is observed to fall so much to the right or left, say, due to the varying causes of drift, wind, etc., the gunner immediately, and without running to his range table, corrects by making the necessary allowance on the deflection scale.

He knows what a division on this scale means for any range.

"It is from this basis—of observed deviations,—then, that our gunner must learn his art." "It is from that basis that the infantry marksman has acquired his skill; and the gunner to reach a similar goal must travel a parallel course."

Judging distances, etc.—In the matter of judging distances to fixed and moving objects, and the rate of movement of the latter, my experience and my observation of the experience of others, give me very little confidence in its reliability. Even the valuation placed on these particulars in the schedule in question is confessedly small. A man who *can* approximate ~~a~~ distance would be an invaluable adjunct in an organization; but it is a faculty not easily acquired; it is seldom innate. In passing, it may not be amiss to cite a practical example. I have seen the statement that in 1893, at Fort Riley, the estimates of a certain range by the officers of one light battery varied from 700 to 1,500 yards. Again, in 1894, another battery, firing at unknown distance, began with an elevation for 3,000 yards, but reduced it to about 1,700 yards before finding the target. In this case, however, it is stated that the range was obtained within the time limit of five minutes. Under the circumstances, this feat, finding the range within five minutes, would seem to enhance the value of the gun as a range-finder; it puts little premium on the process of guessing.

It may be remarked at this point that each field battery of this regiment (and presumably others) is supplied with a range finder, the Weldon, but it is not understood that the instrument has been permanently assigned for use. Its practical utility has certainly not been generally acknowledged. I read that the German field batteries, for instance, do not carry a range-finder. It constitutes, however, a part of the equipment of English batteries, but for limited purposes. If it is to be retained in our service, the gunners will of course be taught how to handle it. The Drill regulations remark about this subject,—"the range is found either by trial shots or by means of the range-finder. the latter should be used whenever time and circumstances permit." * * * "It will nearly (?) always be practicable to use the range-finder at the first position occupied and sometimes at the subsequent positions." Here is a wide margin for the exercise of discretion.

Just a passing word as to the practical side of this question. The term range-finder is a misnomer; *distance* finder is far more correct. The range-finder does not find the *range*; it simply gives a distance, more or less accurately, dependent upon the expertness of the operator and upon the conditions under which he is working. The operation can be done satisfactorily only

when there is plenty of time. The results too, will be more than likely unreliable if the observer is under strain of excitement, a very natural state during fire or danger. What we want is the relative range; the practical gunner needs to know only his elevation and time. The range-finder gives him merely a hint as to these figures; it *guesses* for him, and the guess is just as likely to be wrong as right. But the gun *does* find the range; it is the only reliable range-finder.

A brief consideration of the various causes which influence the accuracy of fire will, it is thought, show the necessity of trial, or verifying shots. The powder charge is ever variable, owing to differences in its weight, to deterioration in strength; and it changes with the state of the atmosphere. The velocity and direction of the wind may be irregular. The jump is not constant. The density of loading may not be uniform. The gun gives us *at once* the proper elevation, with all these varying causes duly accounted for; this elevation will seldom accord with the distance determined by the so-called range-finder.

The question, however, is a mooted one, and will receive its solution only in practical trial; I will pass it with one observation.

It seems to me that the advisability of using the range-finder, its solution, rests on the answer to this question: are we perfectly willing to accept the distance given by it as the true range for the guns, on any occasion, and proceed at once to shrapnel fire?

If so, then its value is established; if not, its use will be found only in giving a hint as to one arm of the "bracket," and I am inclined to believe that it would be used, if at all, for this purpose alone.

Telegraphy and signalling.—While the gunner will not carry or use a telegraphic outfit into the field, he should, for the purposes of communication, be trained in the use of the flag and signal code.

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1. Drills in all the details of the gunner's trade,—always aiming to arrive at precision and to impress upon him also the importance of celerity.

2. Lectures, or short talks by the instructor, on such matters as directly pertain to the gunner's duty, and on the general principles governing the service and action of light artillery.

Concerning drills in general a thought suggests itself. Besides instruction proper, the aim of all drills is to insure a rigid discipline under fire, by training the men to perform their duties almost mechanically,—as it were, by second nature. Our personal experience clearly tells us that mere mechanical exercises and routine quickly become monotonous and wearisome. Drills must, therefore, be made interesting in order to hold the men's attention, otherwise they lose their value. In this particular a care rests upon the instructor. *No drill should be performed against*

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The foregoing birdseye glance over the prescribed qualifications for the sea-coast gunner has been taken with no expectation of finding the schedule generally applicable in the instruction for the field gunner. On the contrary I have sought, by making comparisons, to more pointedly indicate differences and to thus show up in stronger relief what are deemed to be the essential features in the training of the light artillery gunner. One subject of the schedule alone remains for consideration, namely, gun laying, the last to be enumerated but the first in importance.

It is the multum in parvo. But, for gun laying, there must be observation of the effect of fire; this is indispensable. These two elements are indispensable; they constitute, essentially, the whole art and training of the gunner. The matter of the observation of fire is simply mentioned at this time; this subject, I find, has been assigned to me for a separate paper. I therefore pass it, and my subsequent remarks will deal chiefly with gun laying.

Essential qualities in a gunner.—Not every man can be made a good or acceptable gunner; certain qualities are required which all men do not possess. Primarily a man must have an aptitude for this important work. He should be a man of good judgment, of quick discernment. Something more, too, than mere mechanical ability to set a sight or adjust a fuze is desired. Good and correct eye sight is indispensable, but in addition to this quality, the gunner must possess sufficient intelligence to quickly pick out a target verbally indicated to him on occasions when a detailed description is out of the question. In the selection of gunners, care must be exercised that they lay their pieces not only accurately but uniformly, that is, always in the same way, that the battery commander may not have the added task of making allowances for the personal peculiarities of the men. Personal errors must be reduced to an uniform standard,—not readily done with some men.

THEORETICAL TRAINING.

For this training I would devote the time allotted, or required, to:

1. Drills in all the details of the gunner's trade,—always aiming to arrive at precision and to impress upon him also the importance of celerity.

2. Lectures, or short talks by the instructor, on such matters as directly pertain to the gunner's duty, and on the general principles governing the service and action of light artillery.

Concerning drills in general a thought suggests itself. Besides instruction proper, the aim of all drills is to insure a rigid discipline under fire, by training the men to perform their duties almost mechanically,—as it were, by second nature. Our personal experience clearly tells us that mere mechanical exercises and routine quickly become monotonous and wearisome. Drills must, therefore, be made interesting in order to hold the men's attention, otherwise they lose their value. In this particular a care rests upon the instructor. *No drill should be performed against*

time; if its object has been attained in less than the allotted time better then close it.

Scope of the drills.—The following synopsis shows at a glance the ground it is proposed to cover by the drills.

1. Drills of manipulation:

    Instruction in setting sights; in reading sights,—for elevation and deflection. Use of pointing arc, if furnished.

    Use of range table.

    Fuze cutting.

The preliminary drills are necessary to thoroughly acquaint the gunner with the sight, to make him quick and accurate in its manipulation; and, as far as possible, to familiarize him with the essential figures of the range table. Ordinarily these will be dry exercises, but interest must and can be maintained. More than a little, too, depends on the interest felt and displayed by the instructor. Let him assume various conditions, and put the gunners to the task of referring to the range table and by a mental process to arrive at required data for elevation, and for deflection. As men become more proficient introduce a time limit to arouse emulation.

In these drills the gunners are thoroughly taught the rules for making corrections for observed (assumed) deviation, be that deviation the result of wind, drift, difference of level of wheels, or a combination of the same.

Fuze cutting should be done with dummies; otherwise the instruction will be mere theory. The gunner should be practical; therefore his *hands and eyes must be trained.*

2. Drills of application—Gun laying.

    Aiming on a fixed target to ascertain, point out, and correct individual errors.

    Laying on fixed targets.

    Laying on moving targets.

    Indirect laying.

The gunner having learned to correctly and quickly handle the sight, must now be taught how to aim. His eye sight, its accuracy, will now be tested; personal errors will be discovered, and overcome if possible, each man's aiming being made uniform.

Gun laying is then taken up; this forms the chief feature of the gunner's theoretical instruction.

Service targets.—To accomplish the greatest good, gun laying should be carried on, as far as practicable, under service conditions.

Whenever possible actual or *service* targets should be utilized,—not always to be had in variety in the immediate vicinity of the battery park. . Such practice is far more interesting, to say the least, than laying on a blank wall; and surely it is more instructive and profitable. If nothing else it will acquaint the gunner with *service* targets—targets that he will find before him when real laying begins. Unless he is trained to use such objects he will have to learn when he reaches the firing ground,—then too late; he should be prepared beforehand. Therefore, carry out this instruction in the open and use such objects for laying as would naturally present themselves in service; familiarize the gunner with them, and all the more quickly will he discern and pick out a target when hastily or verbally indicated. For example, tell the uninstructed man to lay his piece on woods, or on a house in the distance; in all probability such a man will select some high, prominent tree, or a chimney or well defined gable end; whereas in each case his *service* target is near the ground.

And, in general, let two vital points be impressed on the gunner: *accuracy* and *celerity*. He must be accurate, not alone in setting his sight, in making corrections on the deflection scale, but he must point accurately *at* his proper target; and in all work he must be quick.

Instruction in gun laying embraces a great deal more than aiming; surely more than sighting at a chalk mark. And, not only should natural targets be employed, but in every variety of the exercise should *some special, definite end be subserved.*

Having indicated a target, let the gunners be taught the general principles pertaining to:

1. The selection of *ranging points.*
2. The *ranging process.*
3. The proper *distribution of fire.*

In a discussion of this character, covering so wide a field, it is not possible to do more than deal with or touch upon general features; each would admit of a sparate paper; details cannot be entered into. Moreover the subjects above presented are so commonly understood that references merely need to be made to them.

Ranging points.—They should be selected with a view to assisting the observation of the ranging shots. As a rule they should be on the windward flank of the target to facilitate observation, particularly in the case of a small objective, when the smoke of the ranging shell, drifting in front or in rear, will better indicate "short" or "over." In laying on a long line observation is rendered easier, and concentration of ranging shots is not so essential.

Ranging.—This is a most important matter, and must receive careful attention. Granting the employment of the range finder, ranging may supplement it in order to confirm the distance given by this instrument, by firing a verifying series of shots; it may, too, entirely supplant the instrument. As is well known the underlying principle in all ranging processes is the "bracket" system: those in vogue differ only in their application, either on fixed or moving targets.

In this connection I can do no better than present a few general rules relative to ranging which have been formulated by Captain W. L. White, Royal Artillery, School of Gunnery, Shoeburyness. He has seemingly given the subject a great amount of study.

"The object of the process of ranging is to find out, irrespective of the distance in yards, what elevation must be given to the guns in order that the mean trajectory of the battery may pass through the center of the target, *i. e.*, the relative range, and to determine the correct length of fuze."

To obtain the mean trajectory of the battery it would manifestly be wrong to range with only one gun.

"On coming into action all the guns are loaded with percussion projectiles and laid for the elevation due to the estimated range, and it must be well understood that this loading is to be continued until stopped or changed by the battery commander."

"When a correction in elevation is ordered it should be made by all the guns and not only by one about to be fired."

With the French the initial round is fired for an elevation less by some 200 or 300 meters than the estimated range.

"No shot the observation of which is doubtful must be taken into consideration in making corrections."

During the ranging, for obvious reasons, the battery commander should not be interfered with or spoken to.

Distribution of fire.—The range having been found, the fire must be *distributed.* This character of fire is the normal one. The gunners must be made to thoroughly understand this point, and to turn from the ranging point to their designated or alotted targets. Shrapnel now takes the place of the percussion or the range finding shell; its effect covers a comparatively large front, and is not alone material but moral,—in disturbing aim and delaying the service and work of the pieces. Teach these points, impress them upon the gunners in gun laying that they be not forgotten or neglected when under strain of danger or excitement.

Three kinds of distributed fire may present themselves in action, namely:

In breadth. In height. In depth.

In breadth.—This is the more usual; and is applicable against extended fronts. As against artillery, gun for gun as a rule. As against infantry or a line of cavalry, the pieces are laid on alotted sections of the objective.

In height.—An example is presented in the attack of buildings where it is sought to produce an effect on the whole front at once.

On August 4, 1870, a battery attacking the Chateau of Geissburg was "told off by sections to shell the different stories of the building."

In depth.—As in the attack on villages or on woods. The purpose here will be to drive the enemy not only from the near edge but well within his position, in order that the attacking infantry, after this preparation, may secure the ground, before the enemy can return to it. An example is furnished on page 94, Letters on Artillery, Prince Kraft, in the case of the attack on the Bois de Garrenne. "Masses of infantry were crowded together in this wood. * * * It was necessary to begin by preparing the attack. With this object I divided the long edge of the forest which extended before us into sections, and I assigned one section to each of my batteries. The first gun of each of these units was to fire at the very edge of the wood, and each of the following guns was to fire in the same direction but was to give 100 paces more elevation than the gun on its right. In this manner the edge of the forest and the forest itself, to a depth of 500 paces, would be covered with a hail of shells. The splinters would carry yet further."

Moving targets.—Stress has been laid on the great advantage of natural targets; hence in work with moving objectives necessity must invent them. Roller targets of strong and cheap construction have been suggested, but for our present purpose, our gun laying being attended with no danger, let us cling to the natural or real target. Detach a squad of foot soldiers or a body of mounted men, with special instructions to traverse the selected practice field.

These men will understand the signal code, and may be directed to move up or down the range, across it, and at various rates of speed.

The gunner now finds new but practical problems confronting him.

Moreover this exercise will be instructive in teaching men the appearance of troops at different distances, and in giving them some idea of the rates of their movements—matters not taught in the drill book.

Indirect laying.—This character of laying will of course be resorted to when the target cannot be seen over the sights. Profitable instruction may be imparted during the preliminary exercises. The gunner may obtain a practical insight into the general principles involved and be taught how to use the expedients for giving elevation and direction. He will learn something of the quadrant or the pointing arc and the purposes of the aiming posts or stakes. Detailed methods need not be here described; they will readily suggest themselves to the instructor.

Laying on targets in elevation or depression.—The gunner's training would be incomplete was he not taught to give correct elevation to his piece when the target is on a higher or a lower level than the gun. The proper cutting of the fuze must receive special attention too, in order that the position of burst may be an effective one.

Scenic or panoramic targets.—In case natural conditions are not available certain artificial means must be employed to simulate them. Let us therefore return to the battery park and make use of the blank wall. On its face will be made a rough but intelligible representation of an open country, with its varied features,—its hedges, woods, farm houses, hamlets, hills, crest lines, etc.; with artillery, infantry and cavalry in formation or action. In other words prepare a scenic or panoramic target. The western half of the Cyclorama of Gettysburg, for example, would admirably serve the purpose; our instructional battery being placed on Cemetery Ridge. All the various and varied features of the battle field now appear before us, representing the targets actually seen in action.

But how to use the scenic target; briefly as follows. Place the pieces at a convenient or readily discernible distance in front of the target; indicate any objective represented thereon, be it a battery, a line of infantry, woods, etc. The range is estimated or rather assumed for each objective. Select the ranging point, go through the ranging process; distribute the fire. To enhance the interest, let an intelligent assistant, some one other than the instructor, assume the range. After each ranging shot or laying, this assistant, acting as observer, will report the result,—

'over," "short," or "doubtful." By the above means mimic, actions might be instructively fought over all kinds of ground and against all types of objectives.

From the foregoing hasty remarks on gun laying, and the limits of a paper of this character will admit of general comments only, I think it will be realized that the proper and efficient regulation of fire is a very important matter, and attainable only after much practice and the rigid enforcement of fire discipline, of which the several subjects enumerated above are essential features.

Being so important the great need of carefully prepared Artillery Fire Regulations for our service is apparent. We stand today practically without a guide. Consider but one element of the problem, the first requisite for obtaining good effect of fire, namely, ranging. This must be done according to some system, and that method should be uniform for all batteries. The personnel, each individual, must know precisely what to do and at the right moment. What, may I ask, are the proper commands of the battery commander for ranging, for shrapnel fire, for changing an objective?

If my meaning is understood by this simple example, then my purpose in dwelling at some length in the beginning of this paper upon the want of prescribed instructions for the training of the personnel of field artillery is explained, and I hope excused.

Lectures or talks.—In addition to the drills, I believe it would be productive of much good if a course of short lectures on the general principles of the profession was given the men. A man will be a better light artilleryman, a better gunner, if he feels that his arm is a valuable one, that its function is important. To raise his profession in his estimation is but to enhance the interest he will take in it and its details,—to elevate his dignity and call forth greater pride. Nothing abstruse or scientific need be entered into; and by all means let the talks be "off hand." Much will come out during the talks which will find useful application in practice. My meaning will be better understood by a suggestion, and I offer the following merely as a crude illustration.

Subjects for lectures.—A series of, say, twenty, during the period set apart for theoretical instruction.

1. The gun; its construction; development; nomenclature, weight, etc.; the carriages, etc.

2. The common shell; construction; weight; uses in ranging and against what character of targets, etc.

3. The shrapnel, time and percussion; construction, weight; how charged; its uses; general principles of shrapnel fire; what occurs on burst; height and effective position of burst, etc.

4. The canister; construction; uses; ranges.

5. Marches.

6. Camping.

7. Cover for field artillery, natural.

8. Cover for field artillery, artificial. Alternate the lectures with practical work in throwing up cover.

9. Requirements of a good position for field artillery; illustrate by examples. point out local positions, good and bad.

10. Bringing batteries into position and action.

11. Effect of ground on fire; in ranging; effect on cone of dispersion of ground sloping to and from battery; effect of ground on ricochets and protection afforded.

12. Fire tactics; fire superintendence; direction, control, management.

13- Fire discipline; why so essential with rifled guns; "all orders to be repeated and not interpreted;" mechanical precision under fire indispensable; every man should do his duty and his only; the battery is the fighting unit, it must respond to the gentlest touch of the captain.

14 and 15. Transportation of artillery; embarking; disembarking.

16. Treatment and care of horses, particularly in the field.

17 to 20. Achievements of field artillery, illustrating by examples.

PRACTICAL TRAINING.

The practical training of the field gunner is his *real* training; he now applies what he has learned theoretically, and is further taught many features not possible of execution during the preparatory stage. In this, his practical work, he deals with actual conditions, projectiles, powder, and varying influences; in other words, he studies *effect*, and learns how to utilize or obviate it.

This training, of course, can be had only during the firing practice of the battery. For such firing, the allowance of ammunition being unfortunately very (too) small, the gunner must make, or his officers must make for him, the most of his opportunities. The matter of the observation of fire here enters as a new but vital factor and all officers as well as gunners must take advantage of every means to observe and study the effect of fire.

Such means are best afforded by service with the range party. As before stated, the observation of fire will be discussed in a separate paper.

Firing practice naturally divides itself into two distinct classes, as follows:

1. Range or unknown distance firing.
2. War or Service firing.

The first is intended to be strictly instructional, or preparatory; in its nature it is suggestive of the infantry "sighting shot;" or the "getting on the target," so to speak. Needless is it to remark that this practice, at known distances and under certain known conditions, should be carried on with the greatest possible care and deliberation,—every effect being well weighed which will enhance the results of the service firing.

The second stage or war practice is the desideratum, and must be executed under the conditions to be met with in actual service.

By far the larger portion of the ammunition allowance should here be expended. It is time we get out of the old rut and enter the field of unknown distances and natural targets. The boy who never goes near the water will never learn how to swim. To fire the entire ammunition allowance at two or three known distances is instructive in so far as it goes, but it does not go far enough; our enemy will not tell us his distance nor can we expect him to remain stationary under our fire.

The practical instruction and target firing of the field batteries serving at this post is governed by regulations laid down in Circular, dated September 14, 1874, Headquarters Department of California; their field work will doubtless conform thereto. The Circular is comprehensive, and outlines a seemingly complete and thorough course of practical firing. Service practice is given the greater prominence. Competitive practice may also be introduced, in the discretion of the Department Commander, when the batteries have finished the full service practice.

Rather than attempt to offer suggestions and ideas of my own relative to the details and methods for the gunner's practical training, which for want of the same could not be founded upon experience but would be based on various publications and reports to which all have access, I beg leave to briefly rehearse, as more profitable, the essential features of the schedule or system prescribed in the said circular, and thus bring to a close this already long discussion.

In general, the following rules are laid down for ranges and targets:

Ranges: The ranges shall, as a rule, be included in the first and second artillery zones, and shall be unknown except with respect to a small portion of the allowance for elementary practice, which will be expended at known distances in teaching the accuracy of the gun and ascertaining the skill developed by the gunners as marksmen or in exhibiting the dispersion and effect of shrapnel ammunition. Targets: In elementary practice for *effect*, in service and competitive practice, the targets shall be silhouettes of infantry, cavalry and field guns, placed in position to represent an enemy under different conditions as to formation and cover usual in active service.

Known Distance Practice.

This firing has for its objects:

1. Testing accuracy,—to ascertain the skill of the gunners.

2. To range and find the length of fuze by trial shots; to teach and practice fire discipline; to teach observation of fire, and its regulation in range and direction; to teach officers and men practically their duty.

The targets herefor may be natural objects, points marked by streamers, dummy figures, and any kind of moving target.

3. To determine *effect*, with an ammunition basis. At the end of the ranging, a series with an ammunition limit of 8 or more time shrapnel should be fired at about 2,500 yards at one of the battery targets corresponding to the zone.

4. To determine *effect*, with a time limit. The battery should be ordered to fire, without approaching within 1,700 yards, on one of the battery targets corresponding to the zone, remaining in action (say) six minutes, time being taken from unlimbering in the firing position.

The circular prescribes that the ranging practice should be had over at least four ranges and on two moving targets, between 1,700 and 3,500 yards, and the allowance of ammunition is fixed at about 4 percussion shell and 6 shrapnel for each range and moving target.

It would appear from these figures that a battery is expected to find the range in about 4 rounds.

Service Practice.

This practice requires a large irregular ground, permitting fire without danger in all directions and variations in the arrangement and appearance of the objectives.

The targets should be arranged as far as possible to represent the different phases of an attack or defense, and if possible, the size of the infantry target for service practice should average 48 dummies.

When practicable, a simple tactical idea for each day's exercise should be made out and executed. The following are suggested in the circular.

The battery to range and fire shrapnel at the enemy's guns,—say, about 16 projectiles in all to be fired.

To change position to repel infantry advancing on another part of the field. Time allowance 6 minutes or as prescribed by the superior commander.

To advance to a range of about 1,500 yards and open fire on infantry who are assumed to be advancing over the second zone; supports being 200 yards in rear of the firing line. Time allowance 6 minutes.

Special instructions as to targets:

a. A battery of artillery in action (supply from caissons) consisting of four guns without limbers; 2 caissons (without teams) 10 yards in rear; 36 dummies, omitting No. 7, but including officers and observer.

b. A company of infantry in single rank, formation for attack, consisting of 48 standing dummies, more or less (officers and file closers included); each dummy to occupy one yard in line.

c. A company of infantry in column of fours, double rank, facing the battery, without officers and file closers, and consisting of 48 dummies, more or less.

d. A line of infantry, consisting of 48 standing dummies, more or less; each dummy to occupy one yard in line.

e. The same as (d) with kneeling figures.

f. A battery of field artillery in action (supply from limbers), consisting of four guns and carriages, four limbers and teams, and 24 horses and 39 cannoneers, standing.

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INDIRECT FIRE.

A lecture delivered before the *Militär wissenschaftlichen und Casino-Vereine zu Temesvar*, By Major-General Moriz Edler von Reichold.

Organ der Militär-wissenschaftlichen Vereine, 1896, No. 4.

During the target practice season of 1894 on the proving grounds near Lippa there was tested a method devised by Major von Brilli, of shooting from a position hidden from the target by accidents of ground.

The satisfactory results obtained by this method by one of the war batteries going through its shooting experiments, of which we will speak later, permits us to hope that Brilli's method has solved the problem, which has been often discussed in the immediate past, viz, that of Indirect Fire.

In the year 1895 a method was proposed by the Technical Military Committee, based on a principle similar to that of Brilli's method, which had already been tested; it is, however, not yet definitely adopted.

If I permit myself to speak at all upon this subject, it is because there is already a division upon it, even in the artillery corps itself. While one side holds that indirect fire for field artillery is an absolute necessity, the other allows it to be used under exceptional circumstances only. I will, at the very beginning remark that I adhere strongly to the latter opinion, not saying, however, that field artillery can do without indirect fire. On the contrary the ability to shoot at unseen objects has become a necessity, which in the future will devolve upon the field artillery.

If the increased range, efficiency and precision of modern firearms have already made the utilization of natural and artificial covers, and the keeping one's self as long as possible out of sight of the enemy of such great importance, so much more will this be the case after the introduction of smokeless powder.

The maxim "see without being seen" is not entirely feasible, even when shooting with smokeless powder, if by "see" we mean the possibility of aiming directly and not merely the possibility of observation by the battery commander. The flash at the instant of firing is even stronger with the new powder than with the black powder, and therefore is more easily seen, so that one must still endeavor to fully shelter his guns by placing them behind a mask with command enough to prevent their discovery.

Covers, or rather masks, which appear to a certain extent advantageous, such as fences, hedges, positions behind the crest of a hill, etc., would not be able to prevent discovery by the enemy and therefore would not answer the purpose. Other covers must be used if one wants to work his guns quietly and undisturbed by the enemy's fire. But such covers will naturally prevent a man at the gun from seeing the object to be fired at, and hence the gun can not be aimed directly.

This will also be the case when the position of the guns is not taken on account of the cover, but is forced upon one by the existing circumstances, such as a wood lying in front, the buildings of a farm with the walls enclosing them, etc., which hide the enemy's position.

If the guns are not to be condemned to inactivity, and if we are not to have a division of fire power, then "indirect" laying must be used.

The employment of indirect laying by field artillery is, however, not a new thing, but has been given a great deal of attention especially since the introduction of the present ordnance.

According to our "Firing Regulations" of the year 1888 indirect laying shall be used:

1. When shooting at very long ranges.
2. When the target is not distinctly visible, for example, in cloudy weather, bad light, etc.
3. When there is a mask before our own position or that of the enemy.
4. When shooting at guns in a covered position.

For these several cases our disposition of existing expedients are, the use of natural or artificial auxiliary aiming points for laying the gun for direction, and the elevating arc for giving elevation. It is however no easy matter for a battery of eight guns, with intervals of 15 to 20 paces, to make use of a common natural auxiliary aiming point. We must therefore often have recourse to artificial ones.

As a natural auxiliary aiming point we make use of some distinctly visible object—a tower, farm house, tree, etc., in the neighborhood of the targets.

As an artificial one, the direction stakes set out in the plane of fire in front or in rear of the guns. The German target practice book allows the use of natural auxiliary aiming points only when the setting out of the direction stakes is not possible. In Italy only artificial points (direction stakes with movable discs) are used. The like holds in Russia. With us, artificial auxiliary aiming points (direction stakes) are used only when no n one is to be found.

We will now consider the process of using indirect fire.

All indirect fire to be of value requires primarily the abil shoot over the cover lying in front, and the possibility of ol ing the effect of the shots from a point lying before, to th of or behind the battery. The question, therefore, is, at distance from the cover shall we be able to shoot over it. flatter the trajectory, the greater must this distance be For the necessary computation more or less practical rules been given. One of the simplest was the use of a table, in the ordinates of the trajectory for the several abscisas w be found. In the end it is still always necessary for the c of the gun to have personal control of the laying of the g order to ascertain whether the trajectory goes over the with the requisite accuracy. The conditions under which rect laying is found to be necessary are the following:

1. When the target can be aimed at directly from one g the battery only.

2. When the target can be aimed at directly from none the guns, the laying of one or of all of them, being po however, from some point in rear.

3. Same as in 2, but when the laying of no gun is pos from a point to the rear. In this case the cover lying t may be (*a*) accessible and sufficiently broad for exploratio example a dam, a hill, etc. (*b*) the cover in front, accessib narrow, for example, a wall, etc.; (*c*) the cover in front, n cessible.

4. When the target can only be seen from a point goi the side of the battery's position or the cover is so far t front that one can not make use directly of the method of ing out the plane of fire.

In the first case.—If the target is not visible from some guns, the laying for direction will be accomplished, by mea cross-bars, from one of the guns which can be aimed direct

In the second case.—If the target is not visible from any guns, but the laying is possible from an elevated point to th the laying for direction will be done by means of a plumb l by holding a sabre blade vertical, and bringing the target, sight, and sight notch into one plane. In this plane of fi direction stakes will be set out, and the positions of the fixed, the elevation being given by the elevating arc.

In the third and fourth cases.—The operation is more cc cated if the target can not be seen from any of the guns, nor from an elevated standpoint in rear or, when the target can only be seen from a point lying on the flank of the battery, or under circumstances when it will not be possible to make use directly of the method of setting out direction stakes, because the cover is so widely removed. In such cases the ordinary methods of aiming are not sufficient, and one is obliged to bring in practical geometry or other auxiliary means, as, for example, the angle prism (*Winkelprisma*).

It is therefore conceivable that the battery commander, rather than use such a complicated method, will if it is possible, prefer to advance even into a dangerous position, from which he can see to aim his guns directly, because of the uncomfortable feeling of not seeing the enemy and coming eventually to be surprised by him. In peace maneuvers, in going through which the batteries will begin shooting as soon as possible, and where there is no effect of the enemy's fire, indirect laying is never used; and even in the later wars, no example of indirect fire is known. To be sure, it cannot be argued from this that the same will be true in the future when we shall have at our command a better method of indirect laying.

By the use of such covered places as above mentioned, we can avoid being seen by the enemy and therefore make his range finding shots more difficult and less effeetive; furthermore, a part of his shells and the fragments thereof will be stopped by the fore-lying cover. But against these advantages stand many disadvantages. Our finding the range will be delayed; by sending forward officers or men our position is soon revealed; a change in our target is hard to keep track of; the shooting at objects in motion is prevented.

It is in general not possible with the present means of aiming to use covers when shooting over masked places in the terrain, such as woods, farm yards, and other localities, where an exploration and therefore a direct marking out of the plane of fire is not possible, or which lie at a considerable distance from the position of our own guns.

The present investigation of a method of aiming which takes into account all the controlling circumstances, seems therefore seasonable.

In our professional literature of the past year we find proposed various schemes bearing upon the solution of this question, and the writer of this paper will now proceed to discuss them in the following important particulars.

The requirements which an indirect method of aiming must fulfill are,

1. The position of the battery must not be prematurely disclosed to the enemy.
2. It must be independent of the range and of the kind of cover.
3. It must permit a quick change of target and also the shooting at objects in motion.
4. The operation of the apparatus devised must be simple and in accordance with conditions of field service.

This last requirement is the most difficult of all to secure.

METHOD OF CAPTAIN ROKNIC.

In the accompanying figure let *Z* be the target, *W* a wood as a mask, and *G* the position of a gun to represent the line of the batteries.

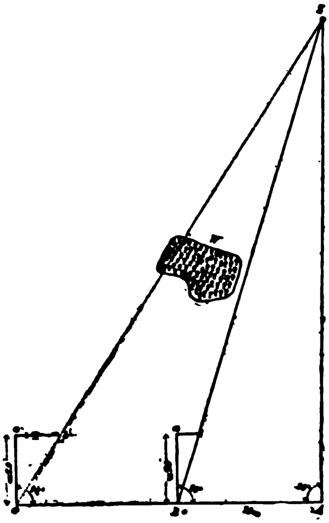

Fig. 1.

Construct the right-angled triangle AGZ, and lay off on the cathetus AG a definite distance AB, so that the target can be seen from B. Erect at B, the perpendicular Ba and at a the perpendicular ab; we thus have two similar triangles abB and ABZ, in which AB and Ba are known and ab can be measured since the target is visible from B; then $ab : AB :: BA : AZ$ from which $AZ = \frac{aB \cdot AB}{ab}$.

Suppose at *G* the right-angled triangle $Ga'b'$ constructed in which AG is measured and $Ba = Ga' = 0.5$ *m* therefore

$$a'b' : ab :: AG : AB$$

and

$$a'b' = \frac{AG}{AB} \cdot ab.$$

The points *G* and *b'* determinethe direct line of sight of the gun. Based upon this geometrical method, Captain Roknic, of the Fourth Corps Artillery Regiment, has constructed an apparatus, which not only makes possible the establishment of two perpendiculars by means of two sights standing perpendicular to one another, but also enables us to measure directly the catheti *B A* and *G a'* and *a b* and *a' b'*.

USE OF THE APPARATUS.

The apparatus is set up at *A* and the target *Z* be sighted over the long sight arms *V* and *K*. While the sighting is being done, two men stretch a cord 75 m long from *A* to *B*, the man at *B* being directed on the perpendicular *V' K''* (over the short sight arms) the apparatus will then be transferred to *B* after setting up a sighting stake at *A*. At *B* the *mm* arm will be revolved into place, the line of sight of the short arm, *K'' V'*, will be directed on *A*; then sighting *Z* over *V* and pushing the sight *K'* along the *mm* scale until it falls in the line *V K' Z* we have only to read off the number of *mm*, which gives the length of the cathetus *a b* of the preceding figure.

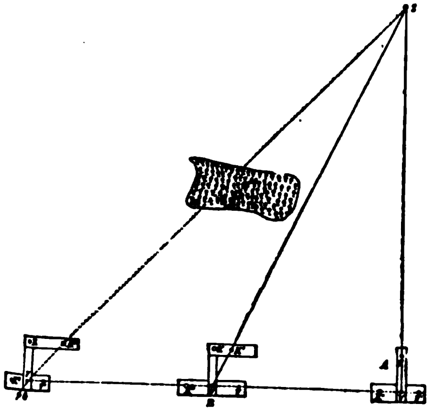

Fig. 2.

Next take the apparatus from *B* to *G* and set it up exactly as at *B*. As previously at *B*, move the sight *K'* to $n \times a\,b$ *mm* $\left[n = \frac{A\,G}{A\,B} \cdot ab\right]$ which gives for the guns the line of azimuth sight in the plane of fire. The transfer of this azimuth to the neighboring guns is accomplished by means of a cord stretched over the sight of the gun and the direction stake. For the concentration of fire the interval of these direction stakes must be a definite proportion of the interval of the guns.

The apparatus can also be used for the approximation of ranges; by means of the similarity of *A B Z* and *a b B* (see figure page 174) there results $AZ : AB :: aB : ab$

$$\therefore \quad AZ = \frac{A\,B}{ab} \cdot aB.$$

The apparatus was tested in the year 1891 on the proving grounds near Orkeny and gave, on the whole, satisfactory results. The instrument possesses however little stability and must be cautiously handled to prevent (spontaneous) derangement. The method is complicated and not suitable for the conditions of field service.

METHOD OF CAPTAIN VON BRILLI.

In the summer of 1890, the then Captain von Brilli made in the camp of Bruck his first published experiments with reference to this subject. He based these experiments upon an angle mirror which he replaced the next year by an angle prism. Brilli's indirect aiming depends upon the establishment of the direction of shooting and the base line perpendicular thereto; further, in making the lines of sight of the guns perpendicular to the base line, that is, making them parallel to the direction of shooting.

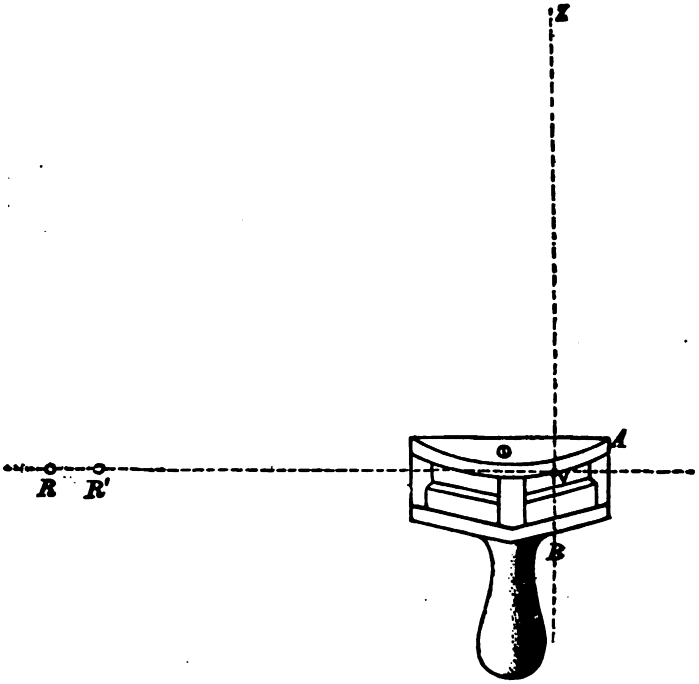

Fig. 3.

This project of Captain von Brilli's was, however, not accepted at that time by the technical military committee, above referred to, and was first brought to a practical trial in the year 1894, somewhat modified, by leaving out the auxiliary cross bars and the use of an aiming contrivance on the ends of the axle of the wheels.

Note.—The following description is taken from the brochure of Captain von Brilli.

For carrying out the indirect method of aiming there are required for every gun one angle prism with staff, for each battery one cross bar and and one angle prism with staff, one sight staff, and two long stakes.

The use of the angle prism to mark out the perpendiculars depends upon the fact, that a ray falling upon the side at an angle greater than 41° 48′ will not be transmitted, but reflected (movable image—single or total reflection); by double reflection the image is constant and makes with the ray of light an angle of 90°. These images will be made use of in marking out the perpendiculars. On the line $v\,Z$ let it be required to erect a perpendicular vR at the point v. Hold the prism in v so that the image from R falls on the cathetus surface AB, at the same time keeping the eye upon Z by looking away over the prism. Bring the mirrored image of R in the prism to coincide exactly with the point Z seen directly. To establish this line Rv bring into it the stake R', marked so as to be recognized when the super-imposed images of the stakes appear in the prism.

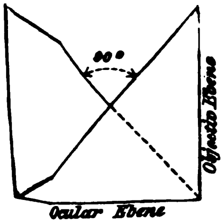

Fig. 4.

The cross-prism is used to mark upon the cover lying before an intermediate point (stand-point of the observer) on the line connecting the target and the battery which are not reciprocally

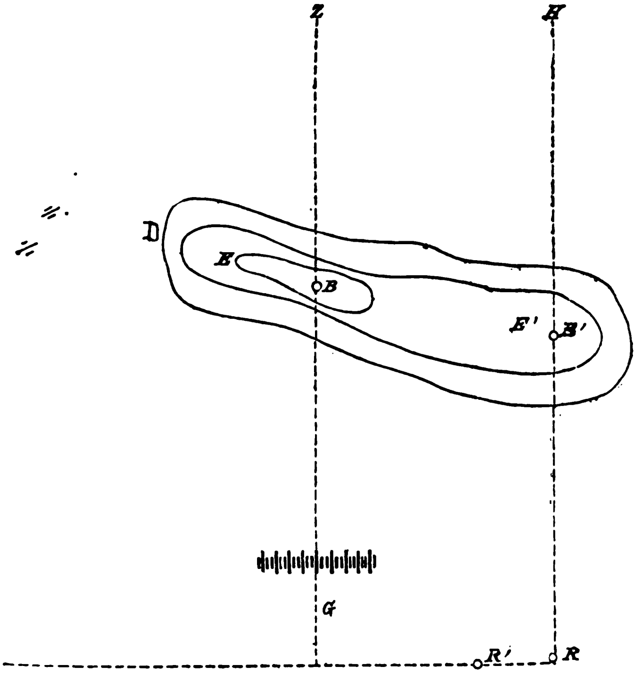

FIG. 5.

visible. This point indicates to the battery the line of fire. The cross-prism consists of two three-sided prisms, the cross-sections being isosceles right angled triangles, of which the hypothenuses are perpendicular to each other and lie in planes one above the other. In the figure, let a point *B* be chosen upon the cover *D* between the target *Z* and the position of the guns *G* (or the point *B'* between an auxiliary aiming point *H* and a high stake *R* situated at the side and a little in rear of the battery). Take the instrument and stand on the point (*E* or *E'*), as the case may be, near the line *GZ* or *RH* and hold it so that the ocular plane is turned toward the eye, the object planes towards *G* and *Z* (or *R* and *H*). The images must now be brought to coincide.

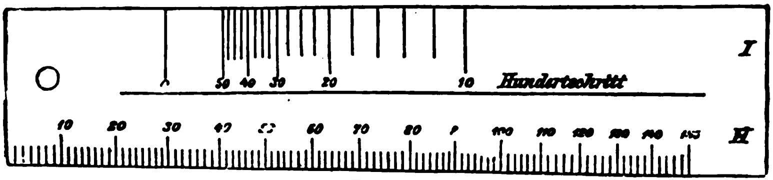

FIG. 6.

The gauging-rod serves to establish an auxiliary point in the terrain just as far to the right or left of the target as the observer himself is to the right or left of the line of fire of the ranging gun. It is about 10 cm. long, made of celluloid and can be made fast with a cord to the highest button of the coat. The length of the cord is so determined that when held taut, the gauging rod will be 50 cm. in front of the eye. There are two scales on the gauging-rod. Scale No. 1 serves to determine the distance in 100 paces of auxiliary points which are situated right or left of the middle of the target. The length of the scale from zero in *mm.*, carried out for the various distances, amounts to $\frac{500}{n}$, wherein $n = 100$ paces. To use this instrument the zero of the rod when held horizontally will be directed on the middle of the target. The second scale is used for measuring the angles of slopes; each division corresponds to two divisions of the elevating arc, and amounts for the distance of 50 cm. from the eye to 1.33 mm. This scale is used also to estimate the bursting height when shooting with shrapnel.

The stakes are two and one-half m. long, 3 to 4 cm. in diameter and are provided with an iron shoe together with a cross bar. In order that they may be more sharply defined at great distances one of the stakes is painted white, and the other red.

THE METHOD OF AIMING.

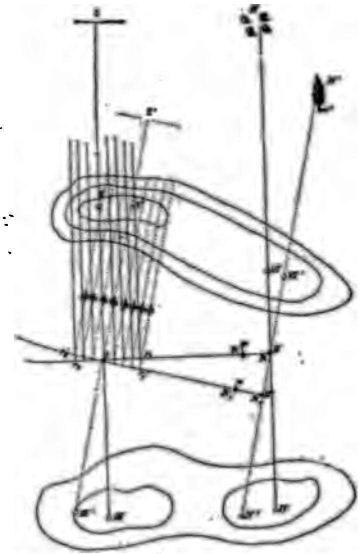

Fig. 7.

1. *The determination of the line of fire.*—The standpoints of the observer are represented in the following figure by the numbers I to VI inclusive. Those numbered I, III, and V lie in the direction of fire from the position of the guns; those numbered II, IV and VI lie to the side of this line.

If the observer stands at I, that is, if he stands a few paces behind the guns from the position of the target, he marks out the base line *R R'* by means of the angle prism. (From the brochure, with consent of the author).

If the observer stands at II, to the side of the battery, he determines first in order, by means of the gauging rod, the auxiliary point *H* in the terrain, lying just as far from the targets as he himself is standing from the ranging gun. At this point II since the observer makes use of one of the long stakes *R*, the establishment of the base line is determined by the adjustment of but one other *R'*.

If the observer stands on one of the high points at III, he directs an assistant on the line of fire at I who from this point marks out the base line *RR'*.

If observation is possible from a point to the side and rear of the battery, as at IV, the auxiliary point *H* will first be determined and an assistant established on the line *H*-IV.

If the target can be seen only from a point in the cover forelying, as V, the point V and from it the line of fire IV will be determined by means of the cross prism.

If the target is visible only from a point to the side and in front of the battery, the observer determines for himself first of all an auxiliary point *H* and directs hinself in the line *H*-II by means of the cross prism.

2. *Laying out parallel lines of sight.*—Direct the instrument towards the targets, standing behind the guns, with the prism, which should be held at the height of the eye, in the base line *RR'*; that is, move forward or backward until the image of the covered stakes appears in the prism. By moving sideways this

image may be made to coincide with the sight of the gun seen directly. To mark out the vertices of the right angles the direction stakes will be held perpendicular by means of the plumb-line, and the images of these stakes in the side of the prism farthest away from R and R' will be made to coincide with R and R' seen directly. The observer's standpoint and the direction stake will then be two points of the line of sight for this gun. In this way all the guns can be laid accurately, quickly and simultaneously. To fix this line of fire when found, direction stakes will be set up at the vertices r_1 to r_8 and the positions of the wheels will be marked. To concentrate the fire the deflection toward the side of the direction gun must be known before beginning the operation of laying the guns.

The amount of this deflection is $$S = \frac{I}{t} = \frac{\text{Interval from direction gun}}{\text{1000 paces of distance to target}}$$

If the gun interval is 10 paces and the range is 2500 then $s = \frac{10}{2.5} = 4\ mm.$

CHANGING THE TARGET.

The form of the Brilli method of aiming makes it possible, even while shooting at one target, to mark the base line $R_1\ R_1'$ ready for the next target intended to be used. To change the target requires then only the time necessary to make the line of sight perpendicular to the plane of the base, which operation can be accomplished in thirty to sixty seconds.

There is no doubt that indirect aiming can be advantageously used for moving targets if one can determine from the direction of motion of the object to be fired at some distinctly visible point in the terrain which it must necessarily pass.

To apply this method of aiming to concrete examples let us describe briefly some experiments taking place at target pratice.

Under the supposition that the battery finds itself ordered to join the left wing of an artillery line already under fire, direct the battery to its place, in front of which, at a distance 400 paces, is situated a wood of large trees which prevents direct sight from the guns to the target. The target in this case is a company in fighting formation, and the firing will be with twenty shell.

Operation.—A non-commissioned officer determines by means of the gauging rod an auxiliary point 30 paces from the middle of the target, that is, just as far to the right (or left) of the target, as his own position is right (or left) of the ranging gun. One of he high stakes is erected at the station of the observer, the other, pproximately half way from this stake to the flank gun of the attery. The base line lies twenty paces behind the guns.

Time elapsed from the first command to the end of laying the uns 2' 30"; to the end of the shooting, 10' 20", number of hits, 5 men by 519 fragments.

At this place the experiment of changing the target was tried, d a further experiment of shooting over a hill was executed nder the supposition that the high ridge lying in front was cupied by our infantry, but that the ascent of the hill was revented by the neighborhood of the hostile infantry as well as e fire of the enemy's own batteries. The battery therefore ot wishing to remain idle found it necessary to mount and treat before placing the guns to shoot over the ridge lying 700 aces in front.

The target, six guns in a firing line, was fired at with nine shell nd twenty-three shrapnel at a range of about 1800 paces.

Operations.—The battery commander and the non-commissiond officer detailed for observation rode to the high ridge lying in ont, where the battery commander pointed out the target to be red at to the non-commissioned officer. The latter dismounted nd placed himself between the middle of the target and the diection gun, by means of the cross prism, which operation occuied two minutes. The delay in getting the guns placed ready r firing was 12' 40".

Result of shots.—Twenty-three men struck by 85 fragments and lling shot; one piece and one carriage disabled; and six horses ruck by thirteen fragments and filling shot.

INDIRECT METHOD OF THE ITALIAN FIELD ARTILLERY.

Meanwhile there was officially introduced in Italy, in the year 893, a a method of indirect laying for the field artillery, deending upon a similar principle. This method uses a four sided rism to lay out the perpendiculars, and differs from Brilli's ethod, in that the base line lies in front of the guns, and the nes of sight are made parallel as before, but by using only e prism from gun to gun. The cross prism is lacking and to ark out auxiliary points direction stakes with moveable discs re employed.

Operation, when the fore-lying cover can be explored.—Two soldiers ount upon the cover or obstacle, and mutually orient themselves n the line $ZB'A'P$ (see Figure).

An auxiliary aiming point F is chosen at 30m in front of the

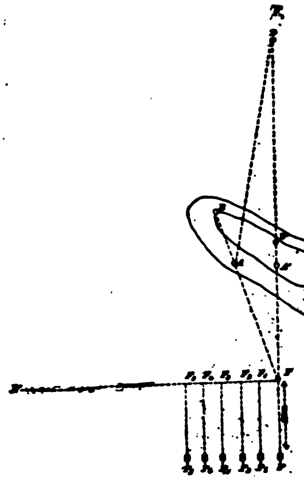

Fig. 8.

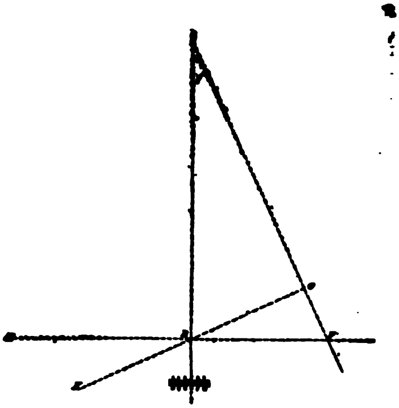

Fig. 9.

gun. At *F* the line *FH*, perpendicular to *PA'B'* is marked out by means of the angle prism. The positions of the auxiliary aiming points $F_1 \ldots F_5$ are determined by an observer with the angle prism, who (at *F*) sees the soldier apparently at *H*. At every point on this line, *FH*, in which the image of the sight of a gun coincides with the stake at *H* an auxiliary aiming point $F_1 \ldots F_5$ will be marked, corresponding to the guns $P_1 \ldots P_5$. However, only parallel laying will be attempted with this method; in order to lay all the guns on the same target at once, it is necessary to correct for the deflection corresponding to the intervals of the guns.

Operation when the target is visible only from one side.—If the observation is possible from *O*, *OZ* will be definitely marked out first and the line *OK* erected perpendicular thereto. On this line *OK*, the point *B* lying approximately in the middle of the battery, will be so chosen that the line of stakes denoting the auxiliary aiming points can be drawn through this point. *OB* and *OZ* will be measured (the latter generally estimated) from which $OF = \frac{OB^2}{OZ}$; in the line *FBH* prolonged, the auxiliary aiming points can now be established. *BZ* is perpendicular to *FH*. The Italians also use Gautier's telemeter which also permits the marking out of right angles.

INDIRECT METHOD OF TECHNICAL MILITARY COMMITTEE.

Although the Brilli method answers very well, the military committee found it necessary to issue directions of their own for indirect fire, which is related to both of the previously mentioned methods, and requires fewer instruments than the Brilli method.

To carry out this method of aiming, each gun is fitted out with a rear sight together with an auxiliary cross bar and a supplementary front sight and each battery with an angle prism. The laying of the gun for direction depends upon the principle of the auxiliary cross arm. It is possible to limit the setting out of the direction stakes, and finally to limit the use of the angle prism to those unusual cases where the extension of the line of fire cannot otherwise be found.

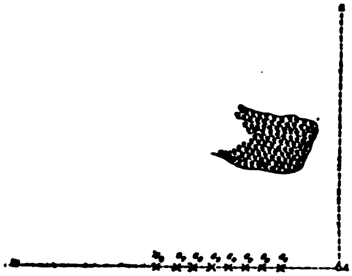

Fig. 10.

The *auxiliary* cross bar is a prismatic rod, and is graduated on both sides with milimeter subdivisions corresponding to those on the cross bar. The point of reference, just as far as the cross bar arm, is the zero of the latter, or the sight notch when the latter is set at zero. To use the apparatus, the auxiliary cross bar will be moved left or right (according as the deflection is left or right) until the division corresponding to the deflection stands over the zero of the cross bar.

With the auxiliary cross arm deflections from 225 *mm* left to 220 *mm* right, can be set off. Since the sight notch of the *auxiliary* cross arm stands about 12.5 *mm* higher than that of the cross arm, so should also the front sight point be set upon an auxiliary sight about the same height in order to avoid complications of shooting.

The operation is similar to that of the Italian method. The direction line *AZ*, Figure p. 182 will first be worked out, and upon it a perpendicular *AB* erected by means of the angle prism. The laying of the different guns upon parallel lines follows as in the Italian method. The concentration of fire at *Z* follows by the use of the auxiliary cross arm.

The firing experiments carried on in the year 1895 and made after the indirect method of aiming will serve to test the inventions used and at the same time will enable a comparison with Brilli's method to be made. The battery received the command to go into action behind a high cover and to fire at artillery—

eight guns in a firing line—; the range was 3000 paces and the target was fired at with 12 shell and 20 shrapnel.

The target was distinctly visible from a standpoint lying about 50 paces to the side and front of the battery. From this point the line of direction leading to the target was marked out, and upon it a perpendicular erected by means of the angle prism. On the base line lying in front of the guns the auxiliary aiming points were defined and the concentration of the lines of fire was determined beforehand by means of the auxiliary cross arm.

A more extensive shooting problem which was solved after this method (the technical committee's), was the following:

The battery received the command to go into action on the brink (edge) of a deep ravine. The target (8 guns in a firing line) stood just beyond an undulation having a command of about six meters over the position of the battery. About 20 paces to the rear of the guns the target was distinctly visible; and it was fired at with 40 shell at a range of 1800 paces. The perpendicular to the direction line was erected at a point 20 paces behind the guns, and 10 paces to the left of the 8th gun.

The positions of the guns were marked out, and the concentration of lines of fire determined beforehand. Time occupied, from the command to the first shot, 10", to the range finding shots, 14"; and to the first shot, 22".

Result of hits.—On the line of the guns, 42 men by 245 fragments; on the line of limbers, 24 horses by 83 fragments.

When one considers the several methods which have been devised and which are herein described, he finds each of them a more or less complicated operation involving the use of numerous auxiliary means and which therefore requires an instrument not particularly suited to the conditions of field service. All things considered Brilli's method deserves a certain preference, by reason of its rapidity of operation, on account of the ability to change the target, and because of the ability to shoot at objects in motion under the circumstances already mentioned. This method has also the priority by right of birth, since the Italian method as well as that of the technical military committee are based upon the same principle.

Finally one possesses in the angle prism a means sufficient in nearly all cases and always at hand when one is established in camp and must have recourse to an instrument. Neither Russia nor Germany have introduced anything of the kind, but Germany possesses in the *Diopter Instrument* (plane table)—an alidade instrument—a means for aiming directly on an auxiliary point. In France they use the angle-mirror binocular instrument of Devé.

RESUME.

The report is concluded by the following epitome.

1. Indirect fire is to be considered an exception.

2. Covered places should, therefore, not be sought out, and should be drawn into only when terrain and tactical circumstances make it necessary. This will occur (*a*) in defensive positions (places prepared beforehand against a definite point in the terrain which the enemy must pass); (*b*) when a weaker artillery in the presence of a stronger finds it necessary to change position under fire; (*c*) when an individual battery in an artillery mass must give itself up to such work because it can do no other.

3. Let us therefore be furnished with the means, in all cases, of using indirect fire whenever it may become necessary. These means should be of suitable proportions for use in the field, whatever the general method. If the correct applications of the rules of shooting be called an "art," so much more does "indirect" shooting deserve the name. Let the "art" however not degenerate into mere artificiality; as in tactics so also in the essentials of shooing "the simplest is the best."

It is moreover entirely settled, that indirect fire although it makes larger demands upon the fire management and service, will be frequently practiced and thoroughly studied on the proving grounds.

Indirect fire must constitute a factor in the development of a battery.

In the future the striking of the first blow in a battle will stand out as a greater advantage than ever before, and the full realization and utilization of the fire power at hand, will also be absolutely necessary. We will certainly in no phase of the action be able to do without the co-operation of the artillery.

[Translated by Second Lieutenant J. A. Shipton, First Artillery.]

HISTORY OF THE SEA-COAST FORTIFICATIONS OF THE UNITED STATES.

III. NARRAGANSET BAY.

(Concluded).

Brigadier-General de Choisy, with a small body to garrison the defenses (600 French recruits and 1,000 local militia), was left at Newport when the French army marched from Rhode Island to Yorktown, Va., the field of glory of the allied forces.

The departure soon after, August 25, 1781, of the French fleet with the heavy artillery and remaining troops to the Chesapeake, obliged the Assembly of Rhode Island further to provide for the defense of the state by mounting additional batteries at North and Brenton's Points, and by strengthening those at Pawtuxet, and Field and Kettle Points, to guard against any approach by Providence River. These were timely precautions, for Sir Henry Clinton had formed a plan to seize the French stores and magazines at Providence and probably to capture Admiral de Barras' fleet at Newport. Fortunately the expedition was accidentally delayed until the 28th, when the bird had flown, much to the chagrin of General Clinton and Admiral Graves, who had anticipated a certain conquest.

The capture at Yorktown, October 19, 1781, of the British army under Cornwallis, virtually terminated the war of the Revolution, and successful negotiations for peace soon followed. Consequently the garrison at Butts' Hill was disbanded in July, 1782.

The war had left the United States with a heavy debt, therefore all expenses were curtailed, particularly those for the military, no longer required. The whole force retained at the conclusion of peace amounted to less than seven hundred men, under command of General Knox; and even this miniature army, before the end of the session of Congress, was reduced to twenty-five men to guard the stores at Pittsburg, Pa., and fifty-five for West Point, N. Y., and the other magazines—in all eighty men.

Without garrisons, our military posts went rapidly to decay, including, of course, those at Newport which had been dismantled. However, by the Act of the Assembly of Rhode Island of October 4, 1784, the fort on Goat Island was armed, the barracks repaired, and the work made to assume "some degree of respectability." It had borne the name of various British sovereigns during its colonial existence of three-quarters of a century; of "Liberty," pending the war of Independence; and, now, it was to assume the name of the illustrious Washington. From this work was probably fired the first salute announcing that Rhode Island, May 29, 1790, had finally joined the Union of the Thirteen United States, by her adoption of the Federal Constitution. Fort Washington,* in 1792, according to the inspection returns, had an armament of three twenty-four, five eighteen, and two six pounders, when the Assembly ordered the "purchase of a reasonable quantity of powder to be made use of at the said fort upon special occasions."

The first European Coalition was made against the French Republic in 1793. Soon, both England and France so grossly violated our neutrality upon the ocean that Congress, in 1794, ordered the building of six frigates; added a corps of artillerists and engineers to our small army; and made appropriations for fortifying our principal ports on the Atlantic Coast. The appropriation for Newport harbor was applied to the works on Goat Island (see plate VI), Bechat Rochefontaine, March 29, 1794, being appointed temporary engineer. He was soon succeeded by Stephen Rochefontaine, who, February 26, 1795, was made the Commandant of the newly organized corps of artillerists and engineers. The name of the latter, as the constructing engineer of the works on Goat Island, is still to be found, neatly cut, upon a stone (turned upside down) in the foundation of one of the new buildings at the Navy Torpedo Station. It is stated, in a report communicated, January 18, 1796, by the Secretary of War, to the United States Senate, that: "For the defense of Newport harbor there have been erected, on Goat Island, a fort, a citadel and an air-furnace. The excellency and importance of this harbor, in time of war, recommend a further expenditure to render the defense complete. To finish the fort, erect an artillery store, and make a covered-way round it, as in a regular fortification, the expense is estimated at about six thousand dollars. There have also been erected a citadel on Tomony Hill, back of the town of Newport, for the protection of its inhabitants, and a battery and guard-house at Howland's Ferry at the Northern end of the island, to keep open a communication with the Main, in case of an invasion. But, to secure effectually this communication, a citadel should be erected on Butts' Hill, that position commanding Howland's Ferry and Bristol Ferry. The cost of it is estimated at 1,800 dollars."

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* The name of "Washington" was given, October 4, 1784, by the Act of the Assembly of Rhode Island.

France had continued her piratical aggressions upon our commerce, and our minister, sent to Paris, had been treated with contempt and indignity; yet, such was the strength of the Gallican feeling among our people, that, not till 1798 were vigorous measures adopted to protect the nation from further insult. The outrageous conduct of the French Directory towards our government; the efforts of their agents to sow sedition throughout our country; their acts to invigorate opposition to the constituted authorities; their disregard of the law of nations and of solemn treaties; their rebuffs of our repeated efforts to adjust differences; their attempts to bribe our envoys, failing which they were expelled from French soil; and their continued seizure of our merchantmen till our losses amounted to $15,000,000, could not fail to rouse the United States to resistance. Forbearance had reached its utmost limit, and at once preparations were instituted to maintain the dignity and honor of the nation. Important additions were made to our navy, and a separate department for its control created; a marine-corps established; many new regiments of infantry, troops of cavalry, and more artillerists and engineers added to our regular forces; a provisional army, with Washington at its head, authorized; liberal appropriations for fortifications granted; our treaties with France abrogated; our commerce with her suspended; and a quasi war instituted by legalizing the capture of her armed vessels, which resulted in several engagements with her cruisers.

With such a threatening aspect of affairs, and an ample justification for a declaration of war, the construction of the sea-coast fortifications was pressed forward with vigor. The importance of Narraganset Bay demanded that full provision should be made for the defense of its main entrance. Accordingly immediate measures were taken to repair and strengthen some of the old works, to rebuild others, and to add an entirely new one. All were placed under the supervision of Major Louis Tousard, who had succeeded Lieutenant-Colonel Rochefontaine, when the latter, May 7, 1798, was dismissed from service. Tousard was born in France in 1749; lost an arm in the action of Butts' Hill, August 29, 1778, during the war of the Revolution; was commissioned a Major of Artillerists and Engineers, February 26, 1795; and was disbanded, January 1, 1802, upon the organization of the present Corps of Engineers created by the law of March 16,

1802. He subsequently was a United States revenue officer, and died in New Orleans, La.

The works repaired, enlarged, rebuilt, and constructed in 1798-1800, for the defense of the main entrance to Narraganset Bay and Newport harbor, were:

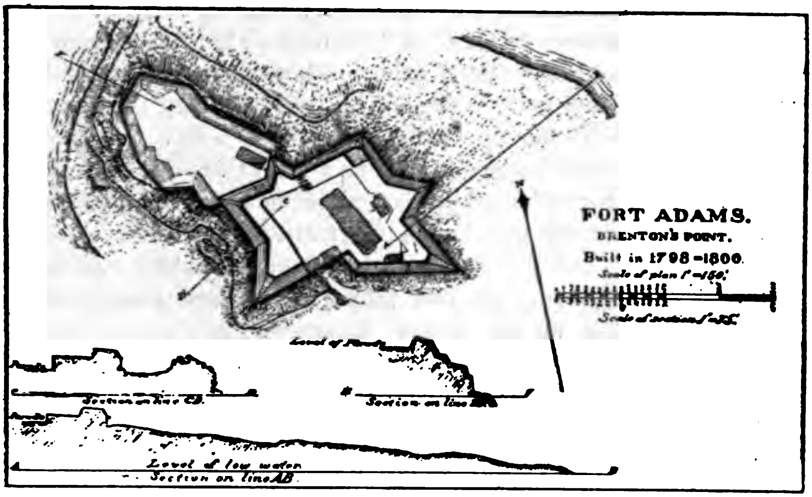

Plate III.

On Brenton's Point, east side of entrance (see plate III), "an enclosed indented work of masonry" for twelve guns, with a brick magazine, and soldiers' barracks, and officers' quarters for one company.

On the Dumplings rock, Conanicut Island, west side of entrance (see plate IV), an elliptical stone tower to mount eight heavy guns on the sea-side, half in casemates and half in barbette.

On Goat Island, in the center of Newport harbor (see plate VI), a small enclosed irregular work of masonry and earth mounting twelve guns, besides flank batteries mounting eighteen guns, with a brick magazine, and soldiers' barracks and officers' quarters for one company.

On Brenton's Cove, south of Goat Island (see plate I, Fig. 3), a small battery occupying the site of an old French battery (Fort Chastellux) on Hallidon Hill.

On North Point, an elliptical stone-scarped battery (see plate I, Fig. 2), for twelve or thirteen guns.

On Rose Island, a regular masonry work (see plate V), with four bastions (two circular and two polygonal) designed for sixty guns, with bomb-proof barracks within for three hundred men.

Of these works, the Dumplings Tower and Rose Island Fort were never finished, armed, or garrisoned. The former is sometimes called Fort Louis; but there is no official authority for th name. Possibly Major Tousard may have so called it after hi own Christain name, or after Louis XVI, who had been our all in the Revolution. It has also been called Fort Brown, havin taken the designation of the old battery near it, so named afte its first commander—"General" Brown—who fired upon th British vessels of war—the Scarborough and Cimetar—April 14 1776, to drive them from Newport harbor. During this centur the Dumplings Tower has been crumbling into a picturesqu ruin; and some years since served as a target for the sensationa Captain John Magruder, when commanding Fort Adams, agai which to practice his artillerists in distant firing. The work o Rose Island was called Fort Hamilton, after the patriot statesma Alexander Hamilton. It has never been used except for quarantine station for the port of Newport.

The elliptical battery on North Point, when completed, wa named Fort Greene, after Rhode Island's most distinguishe general in the Revolution; the work on Goat Island, which ha borne so many aliases, finally, in 1798, was re-christened For Wolcott to commemorate the revolutionary services of Governo Oliver Wolcott, who had just died, December 1, 1797,* its forme name of Fort Washington having been appropriately transferre to the work on the Potomac River opposite to Mount Vernon and the new work on Brenton's Point, when nearly completed i 1799, was named Fort Adams.

An account of the imposing ceremonies of christening thi fort we will condense from the relation given in the *Newport Me cury* of July 9, 1799.

The twenty-third anniversary of American Independenc (July 4, 1799) was ushered in by a Federal salute of thirtee guns from Fort Wolcott; and, before noon, the company c Captain John Henry of the Artillerists and Engineers, Unite States Army, which was to garrison the new work, marched a the head of the column composed of the Major-General of th State of Rhode Island and the Militia Staff, the Newport Ancien Artillery, the Newport Guards, and a large concourse of pa riotic citizens.

The gateway leading to the battery not having been finishe Major Tousard had constructed a temporary arch, decked wit wreaths of evergreens and flowers, and over its key-stone was tablet inscribed:

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*It was also in compliment to his son, then the able Secretary of the Treasury.

FORT ADAMS.

THE ROCK ON WHICH THE STORM WILL BEAT.

At a quarter before twelve o'clock, Major Tousard addressed the assemblage in the following concise and energetic words:

"Citizens! Happy to improve every occasion to testify my veneration for the highly distinguished Citizen, who presides over the Government of the United States, I have solicited the Secretary of war to name this fortress—Fort Adams. He has gratified my desire, and I hope the brave officers and soldiers, who are and shall be honored with its defense, will, by their valor and good conduct, render it worthy of its name, which I hereby proclaim—*Fort Adams.*"

When the address was ended, the American Flag was run up and saluted with thirteen guns from the battery and three hearty cheers from the whole assemblage. The guns from Fort Wolcott returned the salute, as did also the Newport Artillery, the Newport Guards following with the same number of platoon discharges.

After the collation (provided by Major Tousard) had been fully enjoyed, Major Henry's company "paraded in line with the guns of the battery, with the officers in front headed by Majors Tousard and Jackson." The several independent companies, general and staff officers, and citizens passed them in review, the officers and colors saluting. When the column returned under the entrance arch, three guns were fired from the battery, which terminated the memorable ceremony.

Notwithstanding the outrageous treatment of our former embassies to France, much to the surprise of the whole country, President Adams, early in 1799, appointed new envoys to the French Directory; but, before their arrival in Paris, Napoleon was at the head of the new government. With the change of rulers came a change of policy. A qualified treaty was agreed upon, and pending its final ratification Mr. Jefferson, the head of the Gallican party in the United States, was inaugurated President, March 4, 1801, which terminated our hostilities with France.

The Treaty of Amiens, concluded a year later, gave peace to all Europe; but this hollow truce was of short duration. Again our lucrative commerce became a prey to the mandates of Napoleon's Berlin and Milan decrees and England's orders in council. To the aggressions of Great Britain were added those of searching our ships upon the high seas and the impressment of our seamen. The United States temporized till forbearance ceased to be a virtue. War was inevitable; yet, only two years before the sword was drawn, our Secretary of War said to Congress that: "No further appropriation on account of fortifications was proposed in the estimate for the year. But, in case of war, additional works will be required. Their situation, nature and extent, depending upon the emergencies which may require them, cannot be ascertained." The Secretary—William Eustis—being a New England man, deigned to add: "The island of Rhode Island, from the peculiarity of its local situation, bordering on the ocean, accessible at all seasons of the year, affording a safe and commodious harbor, fertile in itself, commanding other islands, well stocked with provisions, and a central station from which to harass the trade of the continent, offers an enemy advantages not combined in any port, and requires additional means of defense." Whereupon this great and liberal statesman recommended: To meet the expenditures required *at this and other places,*" that "*one hundred and fifty thousand dollars be appropriated on account of fortifications.*"

What a magnificent provision to prevent British fleets from seizing this "*central station,*" *and all of our other Atlantic ports*!

According to the report of this Secretary of War, made to Congress December 11, 1811, only six months before war was declared against Great Britain, there were but *seventeen* guns in Fort Adams, and *thirty-eight* in Fort Wolcott, in all *fifty-five* pieces of ordnance, large and small, to defend Narraganset Bay against the most powerful fleets of the world! Doctor Eustis probably proposed to defend our harbors on the Jeffersonian plan, by gunboats ready to be launched upon the appearance of the enemy, or by heavy cannon on traveling-carriages fired by the local militia from the shores of the ports assailed.

President Madison June 1, 1812, sent a confidential message to Congress, in which he recapitulated all the causes of our complaint against Great Britain; her impressment of our seamen; her infringement upon our maritime jurisdiction, and disturbance of the peace of our coasts; her paper blockades, unsupported by any adequate force; her violation of our neutral rights by her orders in council, and her inflexible determination to maintain these orders against all appeals to her justice; her suspected instigation of Indian hostilities against our people; and her conduct, which, taken altogether, amounted to actual war against the United States, while we remained at peace with her.

War was declared against Great Britain June 18, 1812; but, *not till a month after*, was there appropriated by Congress half a million of dollars for coast defense. In consequence of thus rushing headlong and wholly unprepared into a war with the most powerful nation on earth, our seaboard was kept in a continuous state of alarm; our coast trade was almost annihilated; destructive incursions were made into our bays and inlets, even to our capital; and large bodies of militia were constantly being called out, at vast expense and inconvenience, to protect our inadequately fortified harbors. Though no hostile fleets entered Narraganset Bay during the war, the feeble garrisons of the works defending the main channel were kept in constant apprehension; several times the state forces were summoned to resist attack; and many vessels were chased or captured by the British squadron within sight of Rhode Island. Most of these troubles would have been spared to the State by a few strong forts and batteries, the total cost of which would have been far less than the actual expenses incurred in trying to meet them. Congress, in 1816, had to appropriate nearly fourteen millions of dollars to pay the militia required in the latter months of the war.

This war, of 1812—15, had so clearly demonstrated the almost defenseless condition of our sea-coast, that, the year after its termination, liberal appropriations were made for fortifications; and a Board of Engineers was organized to study the whole problem of national defense, and to devise the necessary fortifications to protect the entire coasts of the Atlantic and Gulf of Mexico. This Board was composed of General Joseph G. Swift, the Chief Engineer of the Army; General Simon Bernard, a distinguished French engineer who had done good service under Napoleon; and Lieutenant-Colonels William McRee and Joseph G. Totten, of the Corps of Engineers.

President Monroe, taught by "the faithful admonitions of experience," in his first inaugural message, March 4, 1817, took occation to call attention to the absolute necessity of fortifying our coasts and frontiers, even though it might be at a very heavy expense, as the only certain security against the cost, anxiety, distress, and destruction of property which a superior naval force, with a few thousand troops on board, might at any time impose upon us. He urged, also, the formation of an army competent not only to garrison and preserve these fortifications, but to meet the first invasion of a foreign foe.

The Board of Engineers, April 7, 1820, submitted its projec for the defense of Narraganset Bay, to which there are three entrances. The Eastern, or Sakonnet Passage, was already closed by the Stone Bridge, opposite Tiverton; the Western Passage was to be shoaled with a sunken dyke, below Dutch Island, in such manner as to allow coasters freely to pass over it, but to exclude all vessels of war; and the Middle, or Main Passage, was to be barred, effectually, by permanent fortifications on Brenton's Point, the Dumplings Rock, and Rose Island, while Forts Greene and Wolcott were to defend the inner waters about Newport.

From the report of this Board we learn the condition and value, in 1820, of the then existing fortifications, which had been built in 1795-1800, to be as follows:

FORT ADAMS (see Plate III.), which crosses its fire with Fort Wolcott, and defends on that point the entry to Newport harbor, gives also some fire on the Middle Passage into Narraganset Bay. The tracé of this fort is so irregular, and its angles are so multiplied for no purpose of defense or convenience, that it seems rather the result of chance and caprice than even of the engineering art. It consists of two parts, one appearing to have been added to the other at a later period. The southern part has a development of about seven hundred and fifty feet, measured on its interior crest, and a command of fifteen feet over the country, and forty-five over low water. Its parapet is from twelve to fifteen feet thick, its rampart from twenty-three to twenty-five wide, and its scarp wall less than ten feet high. This part contains a bomb-proof barrack. The northern part has a development, measured in the same way, of about four hundred feet, and has a command of forty-two feet over low water. Its parapet is from twelve to eighteen feet thick, the terre-plein of its rampart is on a level with the parade, on which is a wooden store house and a hot-shot furnace; has no masonry scarp, and is covered with an earthwork six feet high. From these two parts, constituting Fort Adams, about twenty guns could be directed upon the entrance of the bay and as many more upon Newport harbor. The Board of Engineers considered it useless, as it "could neither resist four days against an attack by land, nor contain the formidable armament" demanded by the position.

DUMPLINGS TOWER (see Plate IV.), on Conanicut Island, is an elliptical stone structure, its transverse axis being one hundred and eight feet long, and its conjugate axis eighty-one feet to the exterior of the scarpwall, which varies in height from twelve to twenty-six feet, owing to the inequalities of the site. Under the

terre-plein of the front of the Tower are four casemates, fifteen to eighteen feet long, fifteen feet wide, and seven to eight feet high to the crown of the arch; and above were emplacement for four heavy barbette guns behind a stone parapet of five feet in thickness. Its command, when fineshed, would be fifty-four feet above low water. "When," says the Board of Engineers, "we take into consideration that Dumplings Point is an essential position for defending the central pass into Narraganset Bay, and that the channel is one mile broad at this place, we must perceive that the effect of this Tower is almost null for that purpose, and that its co-operation with Fort Adams, to accomplish so important an object, has never been calculated and is totally inefficient."

Fort Hamilton (see Plate V.). This unfinished work, on Rose Island, is of a rectangular form, six hundred by five hundred and twenty feet, with flanking towers, fifty feet in diameter, on the northwest and southwest angles, and regular bastions at the two other angles. The south front. which sees vessels coming up the channel after passing Brenton's Point and the Dumplings, the east front (except its curtain), and the northwest flanking tower are nearly finished; the remainder of the work being merely sketched. The scarp-walls are low, the parapets where finished about sixteen feet thick, and the rampart twenty-five feet wide. The command of the fort is but eight feet above the ground, and seventeen above low water. Its location, on the site of the old French battery of 1780, is good, as it crosses its fires with those of all the other works. "It is to be regretted,' says the Board

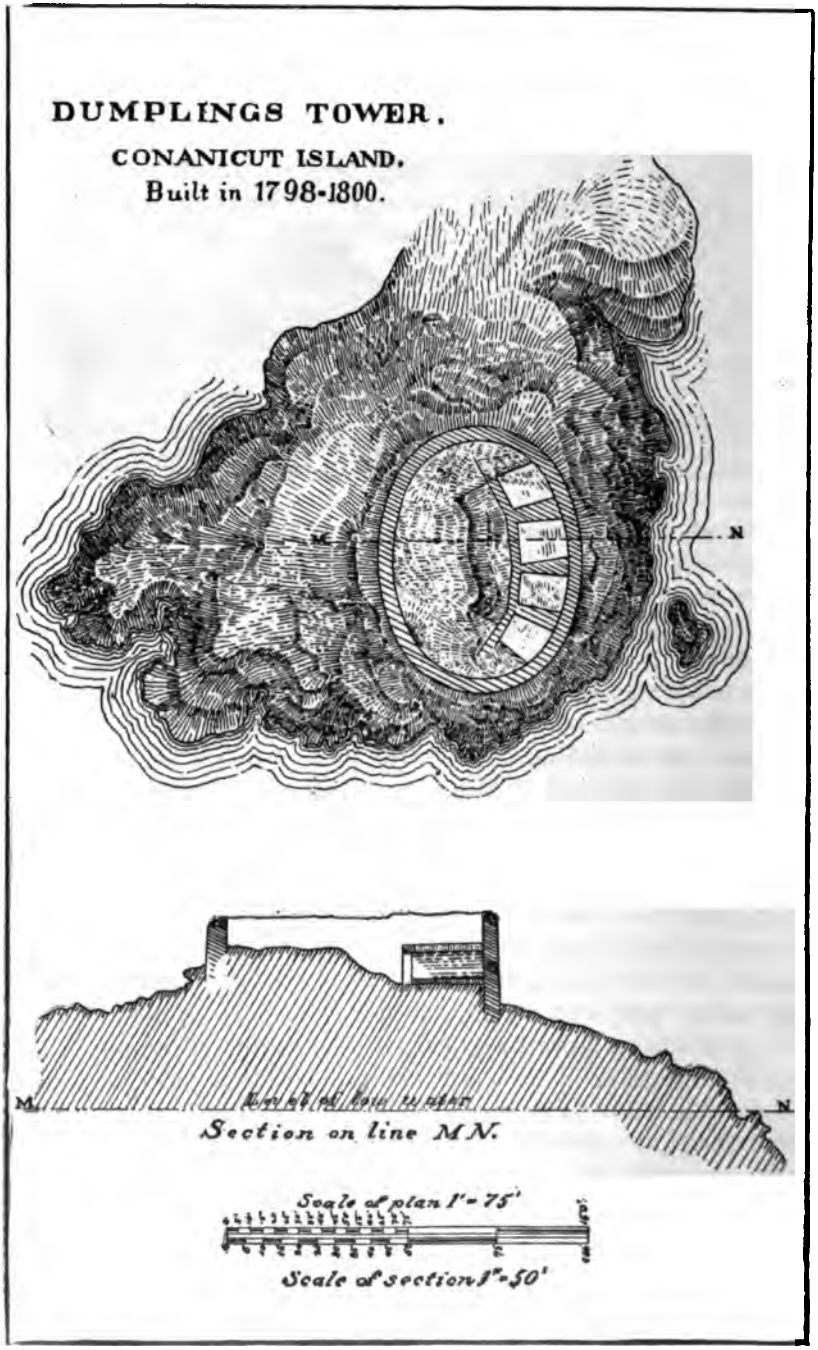
DUMPLINGS TOWER.
CONANICUT ISLAND.
Built in 1798-1800.
M
N
Level of low water
Section on line MN.
Scale of plan 1"=75'
Scale of section 1"=50'

Plate IV.

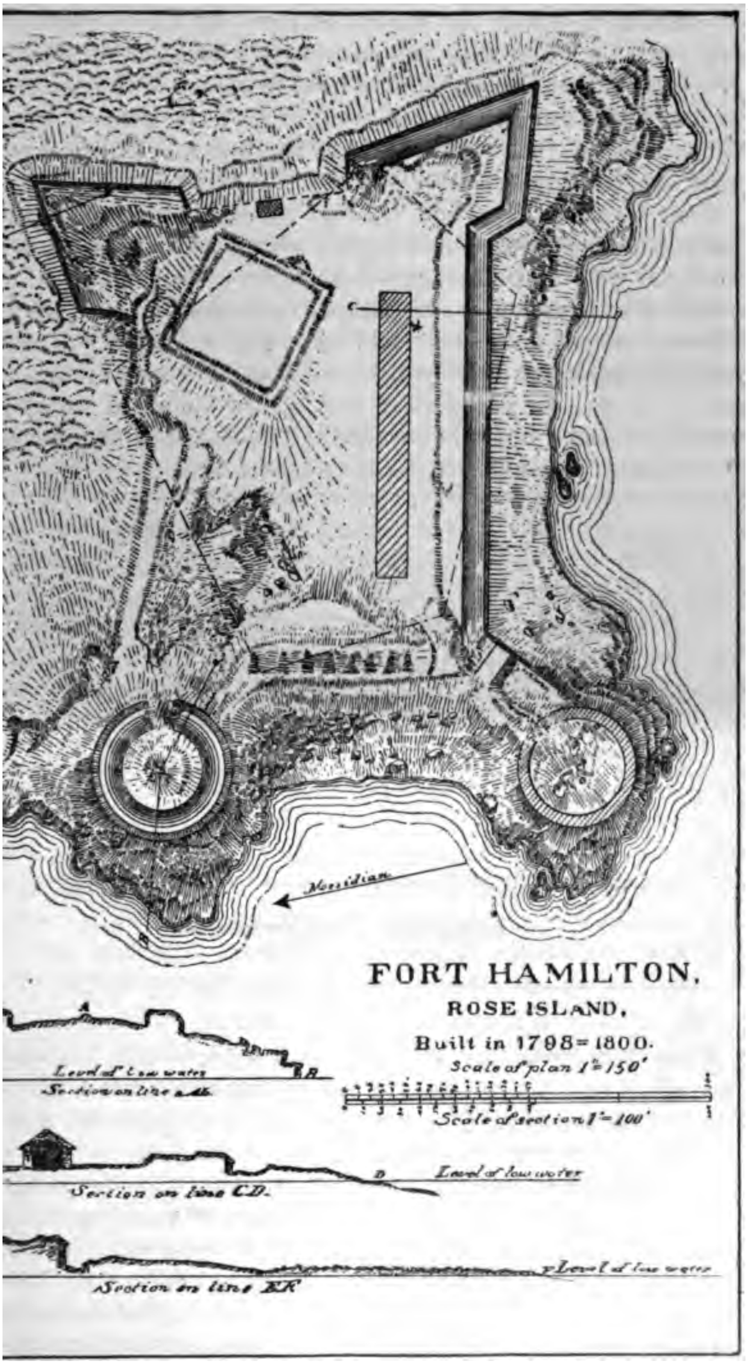
Meridian
C
D
FORT HAMILTON,
ROSE ISLAND,
Built in 1798-1800.
Scale of plan 1"=150'
Scale of section 1"=100'
A
B
Level of low water
Section on line AB
D
Level of low water
Section on line CD.
Level of low water
Section on line EF

Plate V.

of Engineers, "that the sketch of this fort offers none of the requisites for occupying this position in a manner suitable to the principal object which it should have in view. The towers are of no use, and seem only placed there to spoil the general tracé and disposition of the works." The bomb-proof barracks at this work are now untenable.

Fort Greene (see Plate I., Fig. 2), is an elliptical barbette battery for twelve or thirteen guns, with a palisaded gorge. The work has a development, measured upon its interior crest, of two hundred and forty feet; its parapet is twenty-one feet thick; its rampart twenty-six feet broad; its scarp-wall twenty feet high; has a command of twenty-nine feet above low water; and within the work is a brick barrack and guard-house, a bomb-proof magazine, and a hot-shot furnace. The Board of Engineers say, "this battery is sufficient for its purpose."

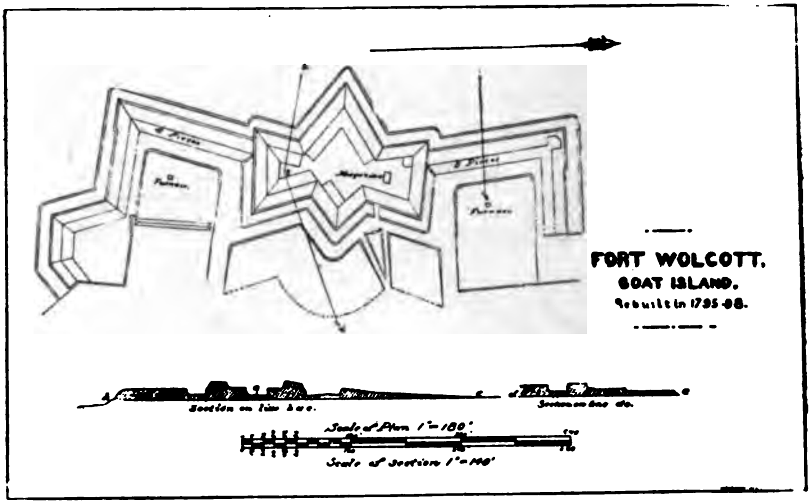

Plate VI.

Fort Wolcott (see Plate VI.), is a large but low battery, having an enclosed redoubt in the middle whose head flanks the front of the battery. The development of the redoubt, measured upon its interior crest, is seven hundred and forty feet, of which three hundred and twelve look towards the sea; its parapet on the gorge is twelve feet thick, and in other parts eighteen; its rampart is twenty-one feet wide; and its command is thirteen feet above the ground and thirty-six above low water. The two wings of the battery measure eight hundred and forty feet of interior crest development, of which three hundred and twenty-five feet are on the right and five hundred and sixteen to the left of the redoubt; their parapets are twenty-five feet thick; and their command is twenty-seven feet above low water. Within the redoubt is a powder magazine; behind the left wing is a brick barrack; and within either wing are hot-shot furnaces. The whole work could mount fifty guns; and its fires, which cross those of Fort Adams and Fort Hamilton, would suffice to cover the harbor of Newport.

From the foregoing description of the works existing in 1820, it will be seen that the Board of Engineers considered those at Brenton's Point, the Dumplings, and on Rose Island as almost worthless; while those at North Point, and on Goat Island, would suffice for interior defense when covered by new channel fortifications.

For the Dumplings, where the United States owns nearly seven acres of land, the Board of Engineers submitted a project, designed by General Bernard, for a very large and costly work. Across the Point, extending from shore to shore, was to be a strong line of three bastioned fronts, with two advanced redoubts occupying higher elevations; and within this enclosing line were to be ten heavy batteries, along the rocky shore, to fire seaward upon ships endeavoring to force a passage through the channel. The entire armament of the work was to be three hundred and eighty-six pieces of artillery of all calibers. This work, never commenced, would be entirely unsuited to the present requirements of this exellent position, where eventually a strong fortification must be built.

For Rose Island, where the government owns twenty-three acres of land, the Board of Engineers proposed a small fort, on the site of the present unfinished work, three hundred and eighty-four yards in perimeter, to mount nearly one hundred guns, in barbette, chiefly on the three sea fronts.

For Brenton's Point, then the most important position of all those to be fortified in Narraganset Bay, the Board of Engineers deemed it necessary to construct, immediately, a powerful work, not only to defend the main entrance against an enemy's fleet, but to hold the position against a large land force till it could be relieved by our own troops, which would require time to be organized and marched to the attack of the enemy. It properly was observed that the strenght of the work should be fully equal to the objects to be secured, that is to provide against such a contingency as had actually occured. Large fleets during the Revolution had invaded Narraganset Bay, and for three years Rhode Island had been held by a strong hostile army which we had not been able to dislodge. It is true that our population and resources had increased, but even in 1820 we were but a feeble power as compared with some of the nations of the old world which might assail us. History was full of illustrations of large fleets and armies being quickly transported to distant points; therefore, there must be no stint in our preparations to meet such foreign expeditions as might be sent to secure a lodgment in Narraganset waters—a bay so capacious, so approachable, occupying so important a strategic position on our northern coast, and acknowledged to be the best roadstead upon our Atlantic seaboard.

"With the opening of this anchorage properly defended, hardly a vessel of war could come, either singly or in small squadrons, upon the coast, in the boisterous season, without aiming at this port, on account of the comparative certainty of an immediate entrance. And this would be particularly the case with vessels injured by heavy weather, or in conflict with an enemy; with vessels bringing prizes, or pursued by a superior force. The use of this port would almost necessarily bring with it the demand for the means of repairing and refitting; and the concentration of these upon some suitable spot would be the beginning of a permanent dock-yard. For the same reason that ships of war would collect here, it would be a favorite point of rendezvous for privateers and their prizes, and a common place of refuge for merchantmen.

"But the same properties that make Narraganset Roads so precious to us would recommend them to an enemy also; and their natural advantages will be enhanced in his eyes by the value of all the objects these advantages may have accumulated therein.

"If this roadstead were without defense an enemy could occupy it without opposition, and, by aid of naval superiority, form a lodgment on the island of Rhode Island for the war. Occupying this island with his troops, and with his fleets the channels on either side, he might defy all the forces of the Eastern States; and while, from this position, his troops would keep in alarm and motion the population of the East, feigned expeditions against New York, or against more southern cities, would equally alarm the country in that direction; and thus, though he might do no more than menace, it is difficult to estimate the embarrassment and expense into which he would drive the government."

Entertaining these views, the Board of Engineers say "the defense adopted for Narraganset Roads must be formidable in the important points, because they will be exposed to powerful-expedition" of the enemy which "may take possession, and bend his whole force to the reduction of the forts on the island, which cannot be relieved until a force has been organized, brought from a distance, conveyed by water to the points attacked, and landed in the face of his batteries; all of this obviously requiring several days during which the forts should be capable of holding out. To do this against an expedition of ten or twenty thousand men demands something more than the strength to resist a single assult. Unless the main works be competent to withstand a siege of a few days, they will not therefore fulfil their trust, and will be worse than useless."

With these premises, in the then feeble condition of the country, very different from the present state of affairs, the present Fort Adams was planned and built. It consists of a pentagonal masonry main-work, bastioned on the three sea-fronts, and casemated throughout for gun-rooms and habitations for the garrison. The principal channel-front has three tiers of fire, the others two, the upper batteries of the whole being in barbette. Covering the two land fronts is a crown-work separated from the main-work by a deep dry ditch, Exterior to all, except the main sea front, is a covered-way with the usual places of arms, traverses, &c. Upon a commanding hill in the vicinity is a formidable casemated masonry redoubt, connected with the fort by an earthen caponnière, so arranged as to form a strong barbette battery towards the ship channel. These various defenses cover about twenty acres, and were designed to mount nearly five hundred pieces of artillery of various calibers. For beginning the construction of this work, Congress, in 1824, appropriated $50,000, of which $22,500 were applied to enlarging the site* to one hundred and sixty-five acres, which were purchased by the United States at various times after 1794. Lieutenant Andrew

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* Brenton's Point, upon which this fort is situated, is the extreme north-westerly point of Brenton's Neck, which constitutes the lower part of the island of Rhode Island south of an east and west line through the Lime Rocks in Newport harbor. The original proprietor, William Brenton, left Hammersmith, England, and landed in Boston in 1634. He brought with him a commission from Charles the First dated 1633, and termed a grant, which allowed him to take so many acres to a mile of all the lands he should survey in the New Englands Colonies, by which authority he became possessed of extensive tracts on the Merrimac River and elsewhere. In 1638, he removed with his wife to the present site of Newport, R. I., and was one of the nine gentlemen, who, February 28, 1639, united themselves into a active body politic for the purpose of forming a township in the Island of Aquidneck, which they termed a "Plantation." In doing this their first object was to choose a spot which would prove the most lucrative situation for a commercial town with a good harbor. Accordingly the place selected was Newport, of which, probably, William Brenton was the surveyor. He had already taken possession of the "Neck" and named it "Hammersmith," in which were two thousand acres of land, having the richest soil and presenting the most picturesque scenery. On Redoubt Hill, where are situated the present quarters of the commanding officer of Fort Adams, he made a clearing in the dense forest and built a brick dwelling, one hundred and fifty feet square, which commanded a magnificent view of the ocean and bay, and was surrounded with well laid parks, beautiful gardens, extensive orchards, silver lakes, and roads and foot-paths meandering everywhere.

Talcott, August 10, 1824, was assigned, temporarily, to the duty of making the preliminary arrangements for building the work; and, February 22, 1825, Lieutenant-Colonel Joseph G. Totten, Corps of Engineers, who had planned it, was charged with its construction. He continued personally to direct the work till his promotion, December 7, 1838, to be the Chief Engineer of the Army, at which time Fort Adams approached completion. Most of the young officers of engineers served their apprenticeship here, this work being a kind of school of application for the Corps of Engineers.

During the war of the Rebellion, the West Passage being entirely undefended, permanent batteries were commenced on Dutch Island, which it is designed to occupy with works mounting sixty heavy guns, arranged in amphitheatre on its southern slope and upon the summit of the island. An interior keep should be added for reserve magazines and other purposes.

Though large sums have been expended upon the fortifications of Narraganset Bay, its entrances are far from being adequately protected against the present heavily-armored steam fleets with their enormous guns. The art of war, like almost everything else, has had its evolution. War-chariots, the Greek phalanx, and the Roman legion, have yielded to the thin formations of modern armies in battle. The sling, the pike, the cross-bow, and the matchlock have given place to the improved magazine-rifle for our infantry. The catapult, the culverin, and the small smooth-bore cannon, have been superseded by heavy rifled artillery, sometimes of pieces weighing one hundred tons, and throwing projectiles of two thousand pounds with prodigious force to great distances. Fleets of row-galleys, of wooden sailing-ships, and of side-wheel steamers, have been surrendered, first for light-plated, and now for the heaviest armored propellers. And, in like manner, thin earthern parapets, masonry scarp-walls, and low barbette batteries are now to be displaced by heavy iron turrets and the strongest combinations of earth, masonry, and shields of hardened steel.

In this changed condition of things our sea-coast fortifications have lost much of their power of offense and defense; yet they are far from being useless, as is often supposed by civilians. On the contrary, they are most useful adjuncts to any new system of works which we may hereafter construct. With our increased population they are still adequate to resist for a sufficient time any land attack; armed with our present guns, converted into rifled artillery, they could protect our harbors against naval marauders, and our channel torpedoes from boat expeditions; and, with slight modifications and some large ordnance, would be able to cope with any, except heavily armed and armored ships. But we must be prepared for *all* future contingencies, hence we require better shielded and stronger armed fortifications.

Fortunately, with the greatly increased range of modern artillery, we have very advantageous positions, within good supporting distance, for new fortifications for the defense of the middle and western entrances into Narraganset Bay. For the eastern entrance the bridges at Tiverton obstruct the passage of ships into its waters.

As we have before stated, Dumplings Point offers an admirable position for powerful batteries to directly oppose the approach of fleets advancing up the Middle Passage.

Lower down are Castle Hill and the Ridge of Conanicut Island, opposite the mouth of Mackerel Cove, both admirable sites for strong citadels, only a mile and a half apart, which distance could be lessened to a mile and a quarter between elevated batteries lining either shore, and protected by the higher enclosed works. Therefore hostile ships, proceeding up mid-channel, would be within the effective range of five-eights or three-quarters of a mile of the heavy armament of these defenses.

The citadel on Conanicut Island, co-operating with another at the Bonnet on the Main, with shore-batteries, would in like manner and at like distances defend the West Passage; while the fires from Dutch Island would enfilade approaching ships.

With such strong works and batteries on these several points, well armed, and aided by properly placed channel torpedoes, Narraganset Bay would be secure against the most powerful armed fleets.

To this new system of more advanced works, Fort Adams would be a most valuable interior adjunct, not only for offense, but as a safe and defensible position wherein to keep magazines and ordnance stores, commissary and hospital supplies, and, at the same time, be a secure refuge for the sick, wounded, and non-combatants.

In concluding this Paper I must tender my most sincere thanks to Colonel Elliot, the Engineer Officer now in charge of the Defenses of Narraganset Bay, for his valuable assistance in making the measurements of the West Passage Batteries, and his great kindness in putting at my disposal the services of his draughtsman—Mr. Mielatz—who has so accurately and artistically delineated the sketches from which the map and plates, illustrating this paper, were engraved.

General GEORGE W. CULLUM,
Corps of Engineers (Retired) U. S. A.

Washington, 1884.

PROFESSIONAL NOTES.

ORGANIZATION.

Spain. Officers of Navy and Marine Corps.

The strength of the corps of officers of the navy and of the marine corps as fixed by royal order of April 21st, of this year as follows:

a. *Navy.*—1 admiral, 6 vice-admirals, 15 rear-admirals, 24 captains of ships f the line, first-class, 47 captains of ships of the line (22 for shore duty), 87 ptains of frigates (37 for shore duty), 117 lieutenants, first class, (43 for ore duty), 313 lieutenants (51 for shore duty), 224 ensigns.

The corps of naval officers was increased by this order by 4 captains, first lass, 6 captains, 17 lieutenants, first class, and 55 lieutenants.

b. *Marine Corps.*—1 field-marshal, commanding the corps, 4 brigadiers, 12 olonels 16 lieutenant-colonels, 32 majors, 140 captains, 164 lieutenants, 80 revet lieutenants (ensigns).

Increase: 1 colonel, 2 lieutenant-colonels, 4 majors and 47 captains.

The Spanish marine corps comprises ordinarily 7000 men, divided into 3 giments (each of 2 battalions of 4 companies each), with headquarters at adiz, Cartagena and Ferrol, a half-brigade serving in Cuba, 2 regiments ach of 2 battalions) on the Phillipines, 4 companies of watchmen for the rsenals, and 1 company of clerks and orderlies.

—*Deutsche Heeres-Zeitung*, August 7, 1897.

TACTICS.

General Questions in Field Artillery Tactics.

There are three questions in field artillery tactics with which military literture has been occupied for several years past.

The first is the question of separating a *corps* artillery or assigning all the atteries to the infantry divisions. This question has not been further eluciated during the past year.

The question of the future armament of the field artillery, still in the foreround of interest, has been cleared up to a great extent. In Russia the eavy gun of effective action is preferred to the light rapid-fire gun. Even ı France, where the idea of a rapid-fire gun had its origin, there has been a omplete revolution of feeling. In other states, too, the tendency to adopt a un of effective single shot action is apparent.

We are still of the opinion that, on account of the mechanical and technical uestions involved, the field gun of the future will have a caliber of from 7.7 o 8.0 cm., and fire a projectile of 7.0 kg. with an initial velocity of (in round umbers) 500 m. The shrapnel will be a base-charged shrapnel with 280 to oo bullets. Such a gun would have a considerably greater effect in single hot action than the one adopted, and would surpass it considerably in mobily and in rapidity of fire.

The character which discussion relative to the field gun of the future has ssumed during the last five years, shows how essential it is for the artillerist, rho desires to form an opinion on this subject, to be not only tactician but lso ballistician; otherwise he will be very apt to go astray.

Closely connected with the question of the future weapon of the field artillery, is that of the organization of this arm, especially the strength and composition of the batteries, which has been so freely and fully discussed in the past year. In the article in the *Militär-Wochenblatt*, No. 13, 1896, "Shall the field batteries be composed in future of four or of six guns?" it was shown that a battery of four rapid fire guns would *undoubtedly* have the same action in fire by either flank as a battery of six guns, since the latter by this mode of firing, which is now and must remain the rule for the actual artillery combat, *cannot* fire any faster than the battery of four guns. But the reduction in the number of guns from six to four would involve many advantages; shortening of the column of march, dimunition of the front of the firing line, easier fire control, and better instruction and training of the battery for war, from which it might follow that the action of the war battery of four guns is actually *greater* than that of six, always, of course, *assuming fire by a flank*. In independent fire the battery of six guns will, of course, have the greater action; but, at ranges liable to arise in actual war, this method is entirely out of the question, since all fire control would thereby be entirely lost. As a disadvantage of the smaller strength it was pointed out that the battery would become more sensitive to losses. With equal distances between pieces, the smaller battery will, under circumstances otherwise similar, suffer less loss, to be sure; but *relatively* the losses (and therefore the diminution in power) will be greater. However, since the battery of four guns can more readily adapt itself to natural cover, or can increase the distances between guns, and thus diminish losses, this disadvantage may be somewhat counteracted. The horses and men thus becoming available by the removal of two guns from each battery may be utilized, without much additional cost, to form four new batteries. The action of 24 batteries of four guns, which each army corps would then have, would be undoubtedly superior to the 20 batterses of six guns in the artillery duel.

If, after the introduction of rapid-fire guns, the same number of men and horses are assigned to the artillery, the battle power of the entire personnel and material (guns and ammunition) will be made most highly effective by reducing the number of guns in a battery, changing a part of the pieces into ammunition wagons, and increasing the number of batteries proportionally.

The always interesting question of the *attack of objects behind cover by artillery* has been considerably discussed in the past year.

The *Revue d'Artillerie* published an article "Curved Fire or Torpedo Shell," which advocated the introduction of a piece for curved fire. Another article in the same magazine, "Actual condition of foreign field artilleries as regards pieces for curved fire and torpedo shell" gives a review of the manner in which the question of attacking troops behind cover with artillery has been solved by the various armies of the world.

The most thorough discussion of the question is that by Captain Prehn, for many years director of the Krupp proving grounds at Meppen: "Shrapnel from field mortars and howitzers." Prehn advocates a 12 cm. howitzer, for which he proposes a shrapnel of special construction, with a charge of high explosive, placed partly in the head, partly in the base. This gun would avoid the objections attaching to the high explosive shel*l* with time fuse—hollow interior of the cone of explosion--as well as to the shrapnel in use for pieces with curved fire—too narrow a cone of explosion.

Firing from behind cover (indirect fire), which, for fear of adverse criticism, practiced with particular energy at all maneuvers, has found a strong adocate in Lieutenant-Colonel Layriz, Bavarian field artillery. In his noterorthy study "The field artillery in the battle of the future and its proper uction and training" he is strongly opposed to firing from positions which, nough occupied under cover, still permit of direct fire. He admits but two des of fire: either indirect fire, naturally connected with occupying the on under cover, or direct fire in case there is great danger in delay and ne greatest rapidity of action is necessary. For the artillery duel he would e only indirect fire. There is no doubt but that the occupation under cover t positions from which the target can be seen has its difficulties, but by pracice these may be overcome; whereas indirect fire, although entirely free rom technical difficulties so long as there is but *one* battery on the battle field, ecomes more difficult as the number of batteries increases. To this must be dded the difficulties of conducting the firing, and the inconvenience that the ommander can see only his own troops or the enemy's at any one time, rarely oth at once, necessitating a portable obeservation ladder. Important imrovements in this mode of firing are continually suggested.

But, there is as yet no good reason to give up the position taken by the iring Regulations, which gives the preference to direct fire over indirect, to oming into position under cover over coming into position exposed to the nemy.

—v. Löbell's *Jahresberichte*, 1896.

[Translated by J. P. W.]

ARTILLERY MATERIAL.

a. *Guns and Carriages.*

ield Gun Constructed by the "Société des anciens établissements Cail."

Since 1891 the "Société des anciens établissements Cail, has been at work t a type of 75 mm. gun which has been tested in various countries, and paricularly in Brazil, where it was employed during the entire period of the nsurrection and gave very satisfactory results, from the point of view of ccuracy as well as that of endurance.

The carriage is of the rigid type and has no delicate parts. By means of he addition of a small spade on the trail and a powerful automatic brake on he wheels, about *three* shots per minute could be fired for several consecutive inutes. This rapidity could have been very considerably increased by the of an arrangement similar to that described further on, which permits the perator to lay the piece for direction at the same time that he gives the levation.

In the opinion of the constructors, a material of this kind must apparently ulfill all the requirements of any field artillery, since, for extreme lightness, t gives a sufficient rapidity of fire and a relatively great power, without any omplication and without using a metallic cartridge case. However, since y are constrained to satisfy the requirements laid down by the countries rom which they get their orders, the manufacturers have built a gun of reater power, from which they have endeavored to realize a very great apidity of fire, without exceeding a relatively small weight for the whole.

Five batteries of this kind have been delivered to the Uruguayan Governent by the "Société des anciens établissements Cail." The 75 mm. rapidre gun described herein, differs from the Uruguayan only in certain particulars principally concerning the carriage.

The information which has been used in the compilation of the present article was furnished us by M. Piffard, Engineer and Chief of the Artillery Service of this Société.

I. DESCRIPTION OF THE SYSTEM.

The system has been especially constructed with a view to increasing the rapidity of fire as much as possible, while preserving intact the quality of simplicity of construction and use, which is essential for field pieces.

The Piece.

Mode of construction.—The piece is composed of a tube reinforced by a jacket carrying the trunnions, in the rear end of which is cut the female screw for the breech-block. A split ring, held in place by a hoop which carries the front sight, unites the tube and jacket.

Breech mechanism.—The breech mechanism of the interrupted screw type is characterized by the ogival form of the breech-screw. The center of the generating arc of the ogive being on the axis of the hinge-pin the entire motion is one of rotation, and the disengagement of the screw is therefore effected without a movement of translation to the rear.

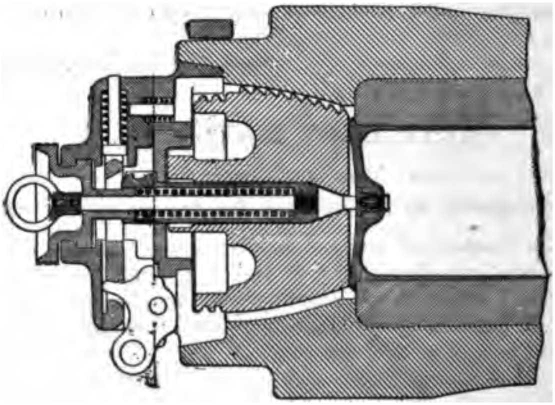


FIG. 1.—Section of Breech-Block. Firing Pin Striking.

The funnel like form of the female portion of the screw facilitates the introduction of the charge, without presenting, however, the large cavity which the simple conical screw would require under the same conditions, consequently without necessitating an unusual size of the part in rear of the jacket.

The opening of the breech is effected by a single movement of the operating lever, keyed on the vertical axis of rotation of the block. This axis in its rotation, draws over a guide-block, with a double rack, sliding in the carrier ring which produces the rotation of the block by means of three geared teeth placed thereon for this purpose. At the instant when the eighth of a turn necessary to disengage the screw-threads is terminated, the movement of the guide-block is arrested by its striking against the breech-screw. The continuation of the motion of the maneuvering lever causes the entire fermeture to revolve round the hinge-pin, and thus opens the breech. A spring bolt situated in the carrier ring, engages in a notch in the breech-screw, as soon as this last movement begins, and thus prevents all rotation while the breech

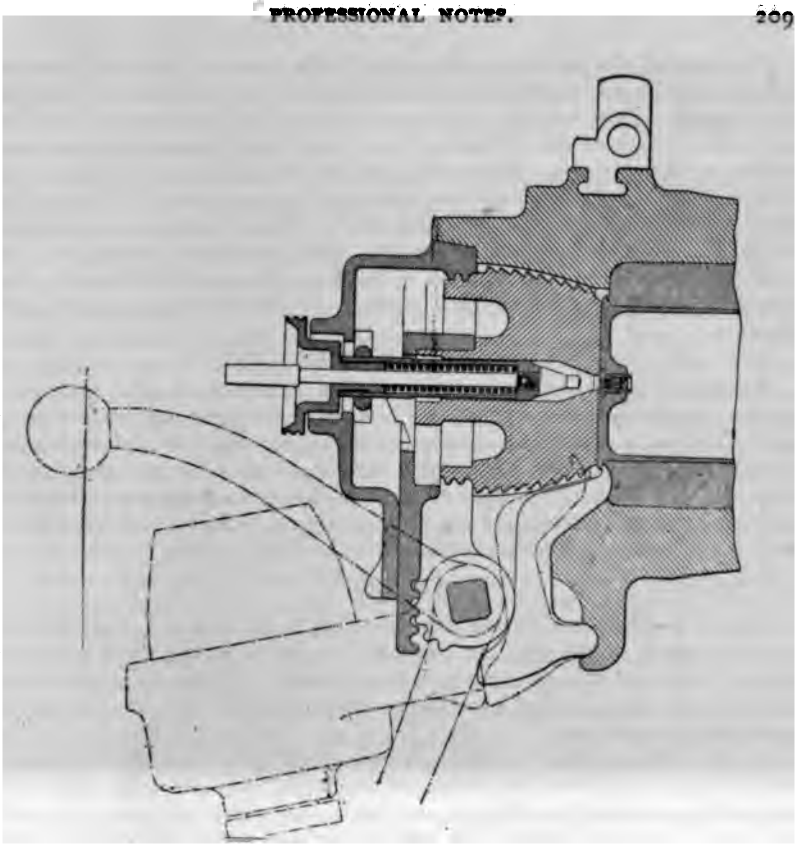


FIG. 2.—Section of Breech-Block. Firing Pin Disengaged.

is open. At the end of this movement the carrier ring strikes the extractor, which consists of a single solid piece without axis of rotation or spring: acted upon by the shock, the latter assures the extraction in a very powerful way.

The breech is closed by the inverse movement of the lever; when the screw-threads are home, opposite their places, the spring-bolt, depressed by the rear end of the breech, liberates the breech-screw, which the guide-block causes to turn so as to engage the screw-threads. At the end of this movement the extremity of the guide-block enters a deep notch of the breech-screw and, acting as a bolt, energetically opposes all rotation during the firing of the shot.

The firing apparatus consists of a percussion lock, with a helical main-spring.

The "arming" of the firing-pin is produced automatically, in the movement of opening the breech, by means of a cam carried by the guide-block; a spring tumbler, which controls a trigger to which is fixed a lanyard, holds the firing-pin armed while the breech is being closed.

The trigger is arranged in such a manner that it is held immoveable by the guide-block so long as the breech is not completely closed; the possibility of a premature discharge is thus avoided. On the other hand, a special arrangement, peculiar to this piece, makes it impossible, in case of a hang-fire, to open the breech until the shot has been fired.

This consists of a particular shape given to the bottom of the cartridge case, which presents a concavity of some millimetres. The front of the breech-screw being a plane surface, it follows, that the end of the firing-pin, in order to reach and explode the percussion cap screwed into the cartridge case, must extend a corresponding distance beyond the face of the breech-screw. In this position, which exists until the pressure of the gas generated flattens the bottom of the cartridge case, the body of the firing-pin lies in an indent or notch cut in the guide-block, holding the latter absolutely immoveable and consequently making the rotation of the block impossible. Safety is thus obtained in an absolute way and without the addition of any special mechanism.

The breech sight and the line of sight.

The breech sight works by a toothed-rack, and is inclined so as to correct approximately for drift. The sliding part has on its upper edge a sight-notch and below that a peep-sight, corresponding, respectively, to the striated point and the cross-hairs of the front sight. There are thus two parallel lines of sight, the one intended for rapid firing, the other for more accurate firing. In using the first of these lines of sight the opening and closing of the breech as well as the loading can be carried on while the piece is being aimed.

Carriage.

General construction.—The carriage is constructed in such a way that the recoiling mass is the greatest possible, the parts resting directly on the ground—trail and wheels—remaining immoveable. This prevents any lateral displacement during recoil due to inequalities of ground or to the wheels not being on the same level.

Cradle.—The carriage is composed of a cradle of bronze, which supports the gun by its trunnions, and which, during recoil, slides upon the body of the carriage, comprising the axle-tree and the wheels which are connected with the trail by a sort of chassis. The trail is provided with a spade intended to anchor it to the ground. The brake serves to connect the moveable part to the fixed part. In order to avoid the jump, the chassis rails formed by the upper parts of the flasks and on which the cradle moves, have been given a curvilinear form, with the result that during the entire period of recoil, the moveable part exercises on the fixed part an energetic centrifugal reaction, which increases the effect of the weight of the system in resisting the tendency to jump, and at the same time ensures the forcing of the spade into the ground at the first shot.

This form of chassis rail has, besides, the effect of producing the automatic return of the gun to battery, and consequently does away with the necessity of any special arrangement for this purpose.

Firing brake.—The firing brake, hydraulic or friction, is of circular form.

The hydraulic brake consists of a drum on which is wound a strong Gall's chain (like a bicycle chain) of which the free end is fixed to the rear of the cradle and which during recoil, produces the rotation of the drum around a fixed axis, secured to the flasks. In this movement (of recoil) a sort of radial paddle, secured to the interior of the drum, plays, in the annular space between the inner walls and the fixed central part, the same role that the piston has in the hydraulic brakes usually employed. The circular form of the brake permits it to be made of very small dimensions, even for a relatively great recoil; it can consequently be placed in rear of the axle between the flasks where it will be perfectly protected. Besides, the joints are easily made water-tight; and as the other parts produce no loss of liquid, since the parts of the brake work alternately in and out of the liquid, it requires no refilling, and is therefore always certain to perform its functions without special care or periodical rechargings.

A spiral spring fixed to the end of a small Gall's chain which winds up in an inverse direction to the large chain, on a drum of small diameter, secured to the first, produces the rotation of the brake and the winding up of the large chain during the return to battery; at the same time it assures the exact return of the piece to its original position.

The friction brake, which may replace the hydraulic one, has the same circular form and is similarly controlled by a Gall's chain. With this brake the work of recoil is absorded by the friction of grooved plates pressed together by strong Belleville springs. The rotation of the brake on the return to battery is brought about as in the hydraulic brake, but it was necessary to add a ratchet-wheel system, which is disposed in such a way as to act without shock, and which keeps one of the plates immoveable during recoil, an indispensable condition to the production of friction. In the return to battery on the contrary, the ratchet wheel permits this plate to be carried along and to revolve in an inverse direction to the rest of the brake.

Aiming Apparatus.—The Elevation of the piece is given by means of a toothed arc, carried by the cradle, which works a wheel carried by the flask, by engaging in an endless screw.

The direction for the first shot is given by means of the trail hand-spike; afterwards, since the spade of the trail is fast in the ground, by means of the displacement of the axle, in the axle-box, which serves as a cross-piece or transom for the flasks. For this purpose the axle is provided with a rack gearing in an endless screw carried by the axle-box, which may be moved in either direction by means of a catch-lever.

This very simple arrangement for correcting the aim, since it leaves the axis of the gun always in the axis of the carriage, introduces no cause of deviation inherent in the system, as happens with guns mounted on pivots.

Road brake.—The carriage may be provided with a drag-shoe or a wheel brake with sliding shoes, operated by a hand-wheel.

As a rule this brake is to be used only *en route;* it may however be employed when firing, in exceptional cases, where the nature of the soil makes it impossible to use the spade.

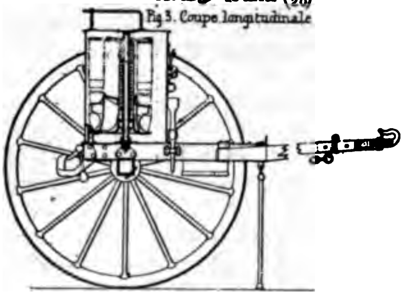
Limber.

The limber, entirely of metal, save the pole, is composed of a chassis to which the axle is solidly attached and on which rests the ammunition chest. The pintle-hook is provided with a counterpoised angle iron, replacing the small pin generally used (as pintle-key) and making the movements of limbering and unlimbering of the carriage very easy and rapid.

Ammunition Chest.—The ammunition chest opens to the rear and is provided with a special arrangement for carrying fixed ammunition (metallic), intended to prevent the deformation of the cartridges and to facilitate their being rapidly removed to the gun. The cartridges are suspended vertically by means of a sort of cup of thin sheet-iron, which receives the projectiles, fuse downward, in supports or racks which can be revolved about tubular axes, these axes serving, at the same time, as transoms of the limber chest. The cartridges are held at the upper end by a screw plate, which the simple rotation of the rack applies to the bottom of the cartridge case. By turning the

Avant-train ($\frac{1}{20}$)

Fig. 3. Coupe longitudinale

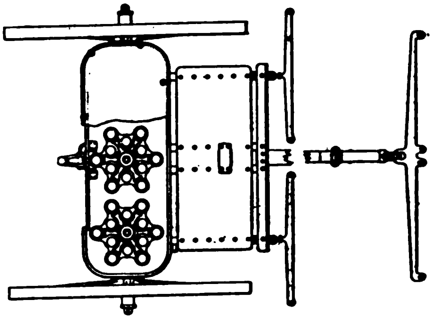


rack in the contrary direction plate is raised, permitting the ridges to be removed as they brought in succession in front c door of the limber-chest.

Each support or rack carries t charges and is itself borne by sp intended to lessen the shocks; is thus obtained an elastic suspe of the ammunition, while the remains firmly fixed to the chass

The cartridges are carried fro limber to the piece by means of these same cups. A sort of handle t them, two and two, for carr each bearer taking four r very easily.

Fig. 4 Plan.



The team is attached by n of two single-trees and a mov splinter-bar for the leaders, is fixed to the spring-hook forms the end of the pole.

Caisson.

The rear part of the caiss of a construction analogous t of the limber. It is provided a drag-shoe or a brake with sliding shoes for the wheels. The chest c caisson body contains five ammunition racks and hence carries sixty r of cartridges.

II. NUMERICAL MEASUREMENTS.

Gun.

Calibre	mm.	75
Total length	m.	2.40
Weight of gun, including fermeture	kg.	340

Carriage.

Height of axis of trunnions from ground	mm.	990
Limits of elevation		− 6° + 19°

Angular value of the displacement of axle		8°
Weight of carriage complete, with wheels	kg.	540
Weight of piece in battery	kg.	860

Ammunition.

Weight of charge of powder (BN_1)	grm.	700
Weight of projectile	kg.	6.430
Initial velocity	m.	530

Limber.

Weight of limber, empty	kg.	370
Weight of limber, loaded (36 rounds) and equipped	kg.	675

Caisson.

Weight of body of caisson, empty	kg.	450
Weight of body of caisson, loaded (60 rounds) and equipped (with spare wheel)	kg.	990

III. TRIALS.

Numerous trials have been made with the material just described by the "Societé des anciens établissements Cail."

We will describe below some of the results obtained in the course of the these experiments.

Ballistic firing.

Rapid firing gun of 75 mm., system of DeBange and Piffard.

No. of shot.	Weight of projectile.	Weight of Charge.	Initial velocity.	REMARKS.
	kg.	g.	m.	
1	5.420	675	559	Powder BN_1.
2	5.420	675	560	Ground dry, mellow, and of slight resistance.
3	5.390	675	561	
4	5.400	675	560	
5	5.420	675	564	Shots 2, 3, 4, 5 and 6 were used to trace the diagram of recoil, reproduced later.
6	5.400	700	577	Judging from other experiments the pressures would have been about 2250 kg. for shots 1 to 5, and 2450 kg. for the following shots.
7	5.400	700	580	
8	5.420	700	579	
9	5.400	700	581	
10	6.720	675	524	
11	6.720	675	521	
12	6.720	675	518	
13	6.720	675	520	
14	6.720	675	521	

Operations of the Mechanism.

In order to ascertain the conditions of recoil of the cradle with reference to the carriage, an index was fixed on the cradle in such a way as to indicate its movement on a sheet placed parallel to the carriage. The comparison of the curve traced by the index when, the peice being at rest, the cradle is moved to the rear by hand, and the curve traced by the same index when the cradle recoils due to firing, enables one to see whether the brake works with regularity.

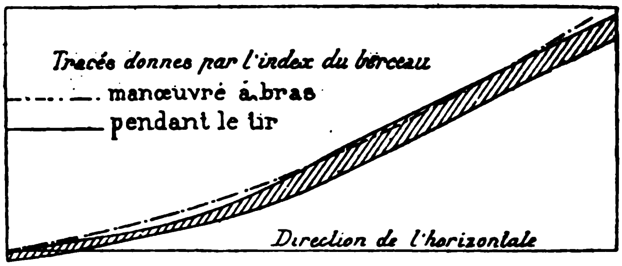

Tracés donnes par l'index du bèrceau
manœuvré à bras
pendant le tir
Direction de l'horizontale

Fig. 6.

This is what is shown by the above diagram, in which the shaded part represents the group of curves corresponding to shots numbered 2 to 6 in the preceding table.

To test the working of the breech mechanism, that of one gun was operated 1500 consecutive times, simulating each time the conditions of fire. No trace of fatique or of wear of the different parts of the mechanism was discovered, the mechanism working perfectly in the firings which followed this trial.

In all the firings, moreover, the *matériel* behaved very well, both from the point of view of durability, and that of operation of the various parts.

The firings carried out so far in the Republic of Uruguay, with the *matériel* delivered to that Government, have, it appears, given very satisfactory results.

The *matériel* has been subjected to various tests as to mobility, which have given opportunity for the observation of the working of the parts; no damage whatever was sustained.

[Trans. by 2nd Lieut. J. A. Shipton, 1st Artillery.]

b. Armor and Projectiles.

Trials of Hardened Nickel Steel-Plates.

Recently the following tests of hardened nickel-steel plates were carried out in France and Italy.

The following details of the trials of two similar surface hardened nickel-steel plates, manufactured in Terni, have been made public:

Dimensions of plates 2.4 m. x 1.6 m. x 15 cm.; caliber of gun 15 cm.; weight of projectile 45 kg.

Shot 1 (against left plate): Velocity of impact 596.7 m. The projectile broke, the fragments remaining in the plate.

Shot 2 (against right plate): Velocity of impact 596.7 m. The projectile broke, the fragments remaining in the plate.

Shot 3 (against right plate): Velocity of impact 620.5 m. The projectile broke, the fragments remaining in the plate.

Shot 4 (against right plate): Velocity of impact 649.8 m. The projectile perforated the plate clearly and remained entire.

Shot 5 (against left plate): Velocity of impact 369.4 m. The projectile broke, the fragments remaining in the plate.

Shot 6 (against left plate): Velocity of impact 439.8 m. The projectile broke, the fragments remaining in the plate.

The following data on the excellent behaviour of a hardened Creusot nickel steel plate were obtained at its trial.*

The plate, 2.9 m. × 2.25 m. × 20 cm., weighing 10.65 t., was subjected to five shots from a 15 cm., L/45, Schneider gun. The details of the trial are given in the following table:

Shot number.	Weight of projectile. kg.	Weight of powder charge. kg.	Velocity. m.	RESULTS.
1	50.98	17.45	625.80	A light crack from the right lower edge of the plate to the point of impact. The projectile broke in pieces.
2	"	17.45	632.80	The crack caused by the first shot is extended to the upper edge of the plate without deepening. The projectile broke in pieces.
3	"	16.96	618.73	The shot, striking near the center of the plate, caused several light surface cracks. The projectile broke in pieces.
4	"	17.51	630.90	The vertical crack caused by the first two shots was enlarged, as well as the surface cracks caused by shot 3. The projectile broke in pieces.
5	"	17.51	632.80	Vertical crack enlarged. The projectile broke in pieces.

The behaviour of the projectiles indicates their lack of toughness.

—*Mittheilungen aus dem Gebiete des Seewesens*, No. VI, 1897.

c. Powder and Explosives.

Some New Features in Smokeless Powders and their Ballistic Results.

The popular idea of an explosive is something which will burn up instantaneously without requiring air to support its combustion, and which may therefore be fired in a confined space. It is hard to dissociate the idea of explosion from that of instantaneous combustion. Yet the differences in the time required for the consumption of different explosive bodies, although too insignificant for measurement by our senses, have a very great significance in their application, especially as gunpowder. Small fractions of a second become very important factors in controlling and directing explosive energy, especially in the attainment of high ballistics in guns.

Explosive compounds are burned in two ways, one by combustion from surfaces exposed to a consuming flame, the other by what is called detonation,

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*This trial took place last year at Creusot. The plates were designed for the armor of the turrets of the Royal Danish Ship *Skjold*. The projectiles (Krupp's chrome-steel projectiles) were furnished by the Danish government.

by which the explosive is consumed nearly simultaneously throughout its mass by a wave action. Combustion from surfaces requiring an appreciable time for the consumption of the explosive body adapts it to use as a gunpowder. The detonative form of explosion adapts a compound to disruptive or shattering purposes, and unfits it as a gunpowder. However, the function of an explosive, whether as a combustive or a detonative compound, is very largely determined by its physical condition, temperature, and the conditions of confinement under which it is fired The equivalent of these conditions is produced when a sufficiently large quantity is fired, and also by the force and temperature brought to bear upon a less sensitive compound by another and highly detonative explosive.

When a rifle is placed to the shoulder and the trigger pulled, the time that elapses between the fall of the hammer and the flash at the muzzle is so brief that it appears to our senses to be perfectly instantaneous. Yet, during this time the firing pin was moved forward and exploded the percussion cap, which, in turn, has fired the powder charge, and a certain period of time has been consumed in the combustion of the powder; the projectile has been started, at first slowly, and then forced along with accelerated velocity to the muzzle, and as the projectile moves away from the muzzle, the powder gases, rushing out at a much higher velocity than the projectile, impinge upon it, and are thrown outwards at right angles to the gun in the form of a disc, in exactly the same manner as though the projectile were held stationary in that position. Such, in spite of the evidence of our senses, is the relativity of velocities and time.

Now, if smokeless powder has been used, such, for example, as cordite, the grains or rods of the explosive may not have had time to be wholly consumed, and a portion of the cords may be picked up in front of the gun, burned down to the form of fine threads, which show that the combustion has been far from instantaneous, and has occurred in a manner similar to the combustion of a stick of wood in an open fire.

It is well known that gun-cotton can be ignited in considerable quantity, and burned quietly away without detonation. Nitro-glycerine in small quantities may be burned like an oil, and even fulminate of mercury may be burned in a vacuum without detonation. Nitro-gelatine, the most powerful commercial high explosive known, may even be used as a propellant, or gunpowder in small quantities and under light confinement.

Fibrous gun-cotton, which consists of an infinite number of small tubes, whose walls, although of a dense colloid, are very thin, owes the facility with which it can be detonated to the fine state of division of this colloid. If gun-cotton be dissolved in acetone, poured on a plate of glass and dried, it is well known how the hard and hornlike product resists detonative influences. However, if reduced to a fine powder its susceptibility to detonation is restored, or if re-dissolved in acetone, and poured into water in a fine stream, a fluffy, fibrous material is formed, resembling very closely the original fibrous gun-cotton, and which will detonate with equal ease and violence.

As practically all explosives may under suitable conditions be consumed by surface combustion, also may all explosives under suitable conditions be detonated. The harder and more coherent the body, the less rapidly it will burn by surface combustion, and the more difficult it is of detonation.

The first gunpowder ever used was, in reality, a powder, and which, although it did not detonate in the gun, was still consumed with such rapidity that its entire consumption was effected before the projectile had moved its length; consequently a sufficient charge could not be employed to impart high velocities to projectiles, without giving excessive initial pressure. It was found that, by compressing the explosive mixture into dense and hard cakes, and then breaking them up into grains, more time was required for its combustion, and that the gases, instead of being all set free at once, the evolution of a portion of them was delayed until the projectile had got well under way, thus giving room behind it for their reception. However, it was still found that the pressure fell off very rapidly because of the diminished burning area as combustion progressed.

With the introduction of smokeless powders, particularly those containing high percentages of nitro-glycerine, the insignificant quantity of solid matter in the products of combustion, and the enormous volume and high temperature of the gases, enabled the production of ballistic results far in excess of of those formerly obtainable with compressed mechanical mixtures. Smokeless powders also presented new possibilities in the formation of powder grains which have been taken advantage of in the Maxim-Schüpphaus smokeless powder, by a system of multi-perforated grains, whereby the burning area may be regulated so that only a desired initial pressure may be obtained, and the powder be consumed with such increase of burning area as to maintain the pressure practically equal behind the projectile through the gun. This renders possible the attainment of the highest ballistic results with an explosive compound consisting almost wholly of gun cotton, and containing, at most, not more than 9 per cent. of nitro glycerine.

Tri-nitro-cellulose requires a large quantity of solvent, not only to dissolve it, but even to render it plastic, and rods or grains formed of it are exceedingly difficult to dry without warping and cracking to pieces; and it is difficult to make it take and retain the exact shape of the forming die. Consequently, unless a very large percentage of nitro-glycerine be employed, a composition must be produced which allows working in a much drier state than ever heretofore attempted, in order that the plastic mass shall retain the shape given it by the die in all its geometrical details. All this calls for special tools, special processes, and a special compound. There are two smokeless powder compounds employed by us, the one consisting of a compound of nirtro-glycerine and mixed gun-cottons, the other of mixed gun-cottons without nitro-glycerine. The first is made by mixing together, in a kneading machine, at a temperature of about 120 degrees Fah. 80 lb. of tri-nitro-cellulose of about thirteen and three-tenths per cent. nitrogen, with 8 lb. of gelatin-pyroxylin of 12 per cent. nitrogen—and soluble in nitro-glycerine below 100 deg. Fah.—12 lb. of nitro-glycerine and 35 lb. of pure anhydrous acetone, adding thereto one pound of pure urea dissolved in pure methyl-alcohol.

The mixture is worked in the kneading machine for about an hour, at a temperature of about 120 deg. Fahr., heated by means of a water bath. The mealy mass is then passed between cold rolls and formed into rough sheets, which are then converted into smooth sheets by passing between slightly warmed rolls. The proper consistence for the mass is easily recognized by the experienced workman by the sense of touch, but the amount of solvent retained may also be easily ascertained by weighing from time to time. Only from 15 to 20 per cent. of solvent should be retained when the compound is ready for stuffing or moulding into grains.

The smooth sheets are compactly wound about one another, to form a roll of the diameter of the press cylinder, the ends preferably being trimmed. The press is kept warm by means of a water jacket, having a temperature of about 120 deg. Fahr. The press filled, the cylinder is preferably exhausted of the air within the space unfilled by the powder. This process, though not absolutely essential, is advisable. The mass is then pressed hard against the head to solidify it. The forming die is now affixed and the compound forced through it at a pressure varying from 3000 to 4000 lb. to the square inch, emerging in the shape of multi-perforated cylinders. The smaller the grain the softer should be the material, and the higher the pressure to force it out. The rods are cut into grains about three diameters long, and placed on shelves in a drying room. When partially dried, the drying is finished in a vacuum.

Several years of experience have shown that after this treatment a certain trace of solvent is retained, but is a constant for each size of grain, and no further drying or other change whatever takes place under service conditions.

The Maxim-Schüpphaus smokeless powder consists either of pure gun-cotton, or of a compouad of 90 per cent. mixed gun-cottons, 9 per cent. nitro-glycerine, and 1 per cent. urea. This percentage of nitro-glycerine we believe to be a decided advatage, and, as has been demonstrated, such a small quantity imparts to the powder none of the disadvantages common to high percentage nitro-glycerine compounds. A powder, made according to this formula, is a very dense, hard, and structureless colloid; and if the nitro-glycerine were to be wholly eliminated from this compound, the gun-cottons alone would not contain oxygen enough and the compound would not burn under the same pressure with equal rapidity, and there would be a falling off in the ballistics. When so little as 9 per cent. of nitro-glycerine is used, the quantity employed in the Maxim-Schüpphaus powder, nothing but a chemical analysis can detect its presence. It cannot be pressed out, and not a particle of it can be volatilized in a vacuum; while, with cordite containing 58 per cent. of nitro-glycerine, it is easy to distil off nitro-glycerine and condense it in a free state.

The nitro-glycerine may be entirely dispensed with, and a pure gun-cotton composition be manufactured after essentially the same method. In this case, we prefer to use about eighty parts tri-nitro-cellulose, and nineteen and one-half parts gelatine-pyroxylin, and half of one per cent. urea. Owing to the absence of nitroglycerine, which facilitates the moulding operation, slightly more solvent is left in the material before pressing. As I have said, it is impossible to evaporate the last trace of solvent from the compound, but, as the quantity remains for ever constant, and never escapes, it does no harm.

We placed 100 lb. of this powder in a room heated to a temperature of 125 deg. Fah. for two weeks, without showing the least loss of weight. Some of this powder was then pulverized and exposed to the same temperature, when the remaining solvent was driven off. Whatever theories and preconceived opinions may be, the true test of a cannonpowder is the test of time and exposure under service conditions.

At the Sandy Hook Proving Grounds in the Uuited States, a quantity of this powder was thrown loose upon the floor in an open room, and there exposed for a period of three years, to the heat of summer and the cold of winter. At the same time an equal quantity was filled into cartridges and kept sealed up for an equal period. Some of the loose powder was then filled into cartridges and fired, side by side in alternating shots, with that which had been kept sealed, with the result that the ballistics of that which had been exposed and that which had been sealed up were identical, proving that the powder had undergone no change whatever.

These powders can be produced on a large scale speedily, economically; and, as the experience of years has proved, they can be produced of uniform composition. The machinery, tools, and processes have all proven practicable and workable commercially, and, I may say, to ideal perfection.

In view of the peculiar treatment to which our powder is subjected in the process of manufacture, we prefer to add a small quantity of urea. The peculiar influence of urea is well illustrated by its use in the manufacture of transparent celluloid, such as photographic films, which, in case they are cut from a block of compressed material and not made by flowing a comparatively thin solution on glass plates or by an equivalent method, could not be produced without the use of this substance, as the temperature to which it is necessary to subject the material causes such slight decomposition as to discolor the product. Urea counteracts this by neutralizing the nitrous acid as fast as formed.

Urea has the further advantage above any other neutralizing substance, in that it is decomposed by nitrous acid into carbonic acid gas, water and nitrogen, leaving no solid product in the material, while it is not an active alkali, and its presence has no effect whatever upon the nitro-compounds with which it is combined. The high excellence of the Maxim-Schüpphaus smokeless powders is well evidenced by the fact that they are now being manufactured and furnished to the United States Government by the world-renowned firm of E. I. Dupont de Nemours and Co., of Wilmington, Delaware, who have acquired the American patent rights.

The following tables showing the results of a few examples of firing with the Maxim-Schüpphaus smokeless powder by the United States army at the Sandy Hook Proving Grounds, and at Indian Head by the United States navy, will be found intesesting.

In examining the following very interesting tables, it must be borne in mind that the Maxim-Schüpphaus smokeless powder fired in these tests contains only 9 per cent. nitro-glycerine. Such high ballistic results have never heretofore been obtained, or anything at all comparable with them, except with smokeless powders containing from 50 to 70 per cent. of nitro-glycerine :—

Some Results of Tests of Maxim-Schüpphaus Smokeless Powder by the United States Navy.

TABLE I.

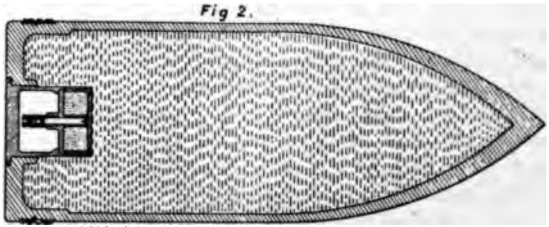
5-in. Breech-loading Rifle, United States Navy.

Travel of shot, 33.6 calibers; powder chamber, 665 cubic inches, priming charge, 28½ grammes of musket powder; date of firing, July, 1896.

The exceedingly high velocity of over 2550 feet per second of the last two shots in the following table, for an average pressure of 34,350 lb., or a little over 15 English tons, is a result which cannot fail to carry conviction with it as to the high ballistic excellence of the Maxim-Schüpphaus smokeless powder; yet this result is hardly more remarkable than that of the first shot in the table, where a velocity of 2148 feet per second was obtained with a pressure of only 21,600 lb. or a little over 9½ English tons.

Charge. lb.	Projectile. lb.	Density of loading.	Muzzle velocity. ft.-sec.	Pressure. lb.
9.3	50	.39344	2148	21,600
11.0	50	.46486	2427	——
11.0	50	.46486	2435	29,600
11.4	50	.48176	2484	30,200
11.75	50	.49656	2559	33,800
11.75	50	.49656	2556	34,900

Fig 2.



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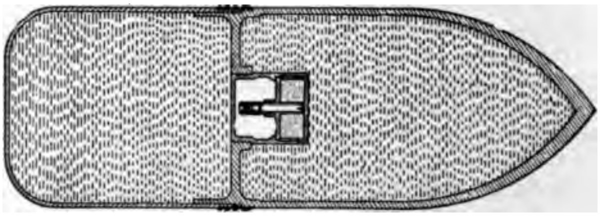

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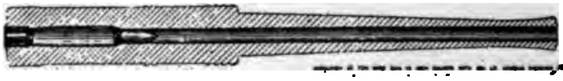
Fig 3.



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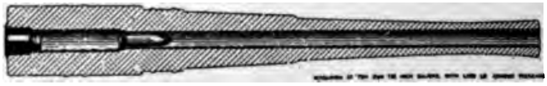

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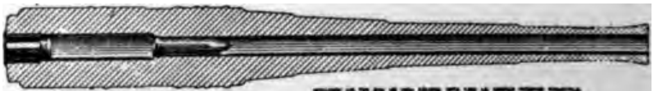

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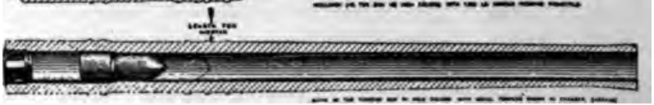

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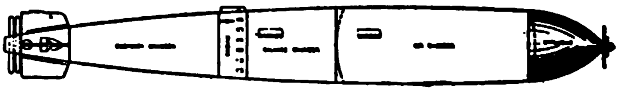
Fig 4



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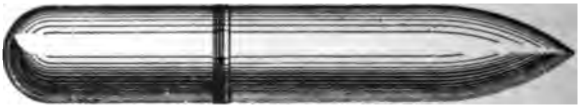

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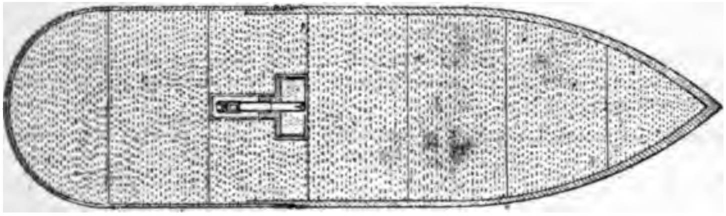
Fig 1.



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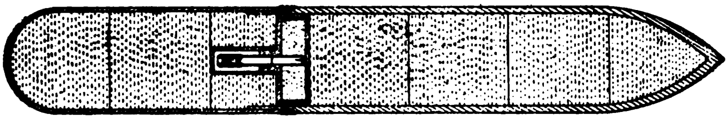

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Fig 7.

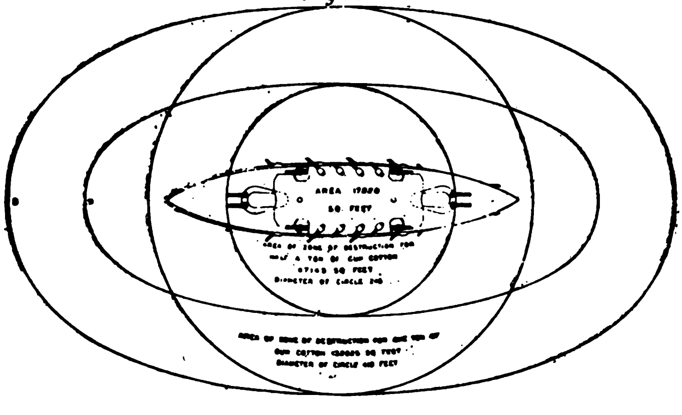
AREA 17020
SQ. FEET
AREA OF ZONE OF DESTRUCTION FOR
HALF A TON OF GUN COTTON
67163 SQ FEET
DIAMETER OF CIRCLE [illegible]
AREA OF ZONE OF DESTRUCTION FOR ONE TON OF
GUN COTTON [illegible] SQ FEET
DIAMETER OF CIRCLE [illegible] FEET

Fig 8.

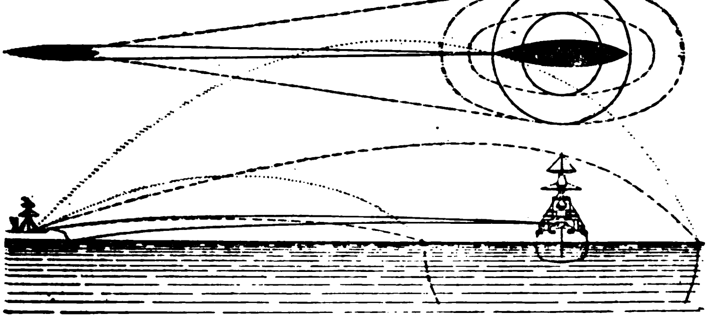

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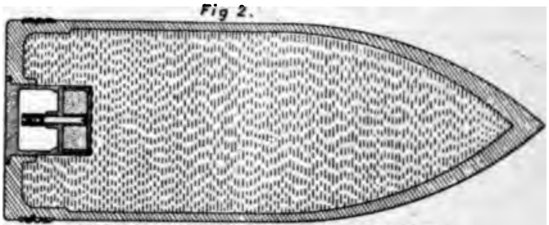
Fig 2.



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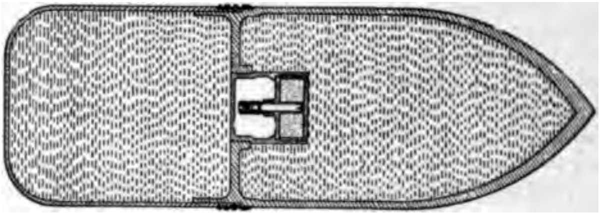

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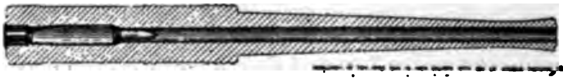
Fig 3.



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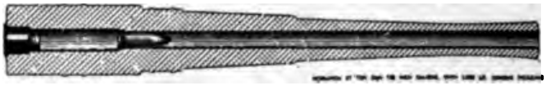

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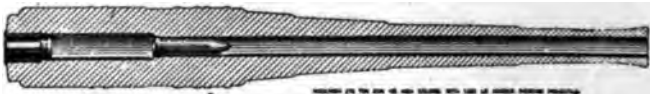

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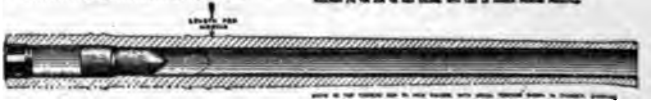

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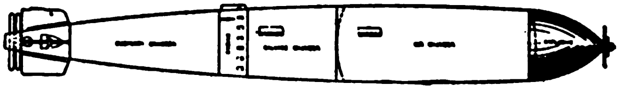
Fig 4



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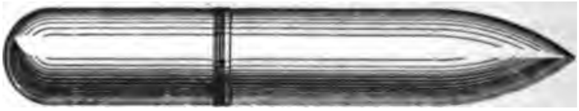

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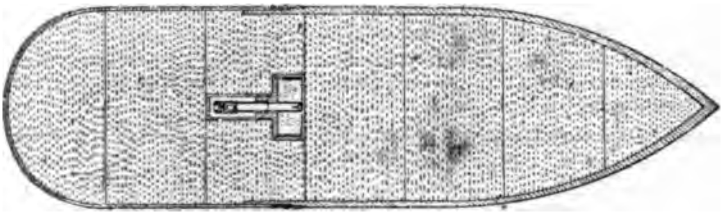
Fig 1.



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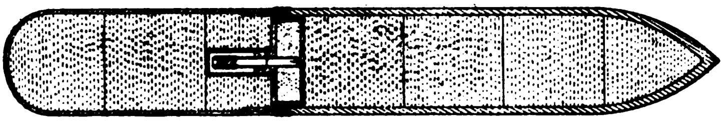

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Fig 7.

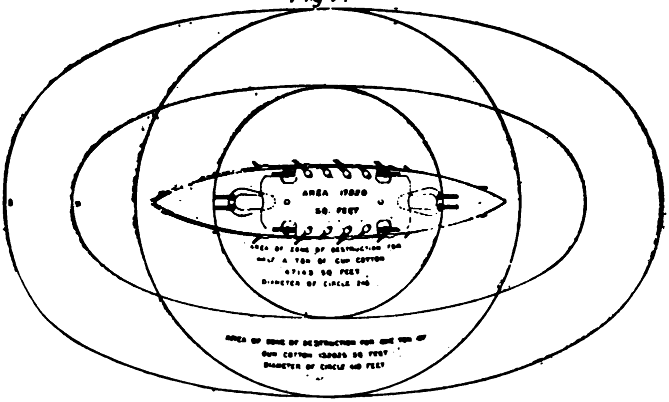
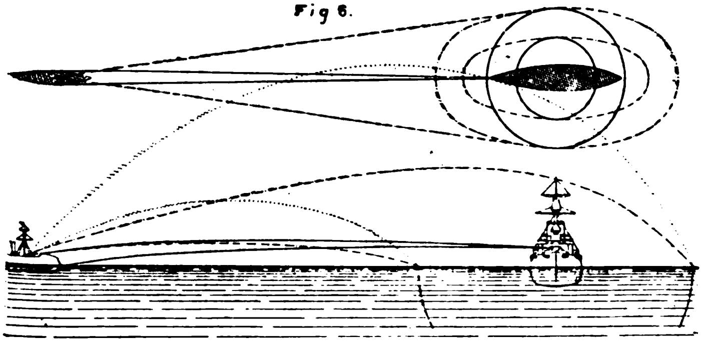

AREA 17820
SQ. FEET
AREA OF ZONE OF DESTRUCTION FOR
HALF A TON OF GUN COTTON
47163 SQ FEET
DIAMETER OF CIRCLE 245
AREA OF ZONE OF DESTRUCTION FOR ONE TON OF
GUN COTTON 132025 SQ FEET
DIAMETER OF CIRCLE 410 FEET

Fig 6.



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determination of distances at which 12,000 lb. to the square inch will be exerted. Fig. 6 is intended to illustrate the destructive efficiency of the blast of high explosives, as compared with the smashing effect of the blow given by the bolts of steel or armor-piercing projectiles thrown from high-power guns, and the difference in the size of the targets presented by a torpedo cruiser and a battleship when the areas about the battleship are taken into consideration, within which an aërial torpedo falling would sink her.

Fig. 7 gives an enlarged plan view of the deck of the battleship, with numbers showing the areas of the zones of destruction within the circles drawn about the battleship.

—*The Engineer*, (London), July 30, 1897.

e. Range and Position Finding.

Description of Lewis Range and Position Finder.

The accompanying photographs show the latest service model of this instrument.

The principal parts are all numbered on the plates, the same notation being observed throughout.

The essential parts are as follows:

First. *A hollow cast-iron column* resting upon three feet, the feet being provided with capstan-headed brass leveling screws (1, 2, 2, Pl. I).

To the top of this column is bolted the cast-iron table. The column should rest upon a solid foundation, preferably of masonry. No especial precaution need be observed in setting up the column and securing the table thereto, except to see that the lag screws are in their proper places and screwed up firmly.

Second. *A circular cast-iron table*, 60 inches in diameter, turned perfectly true on the outer edge, and concentric therewith is turned at the center the seat for the female center (3, 4, 5 and 7 *a*).

Third. *A cast-iron traversing arm* (6) which carries all the other parts of the instrument. This arm is pivoted at the center of the table (male center 7 and 8), and is moved in azimuth by a friction roller device (36 and 35, Pl. II) operating on the outer edge of the table. In front the arm curves upward, so as to clear the surface of the table, and furnishes a support for the horizontal axis of the telescope, and it also supports the plotting attachment (40*a*, 40 and 41, Pls. I and V).

Fourth. *The telescope and its cradle* (9, 10, 11, 12 and 13).

The telescope has a 3-inch object glass, 40-inch focal length, 25 magnifying power, and a micrometer attachment (13) which moves the horizontal cross wire and thus affords an easy correction for abnormal refraction (each division of scale on the micrometer head corresponds to a movement of one ten-thousandth of an inch).

As shown in the photographs, the telescope turns about a horizontal axis (12) in front of the object glass, and all angular movements of the telescope are produced by raising or lowering the eye end at the point where pin (18) rests upon the top (19) of the elevating cylinder (20) called the "point of tangency." The horizontal distance between the axis (12) and this point is 60 inches. Since by construction the elevating cylinder (20) can move only in vertical direction, the point of tangency describes a right line which is the natural tangent of the angle through which the telescope is moved, the radius being 60 inches.

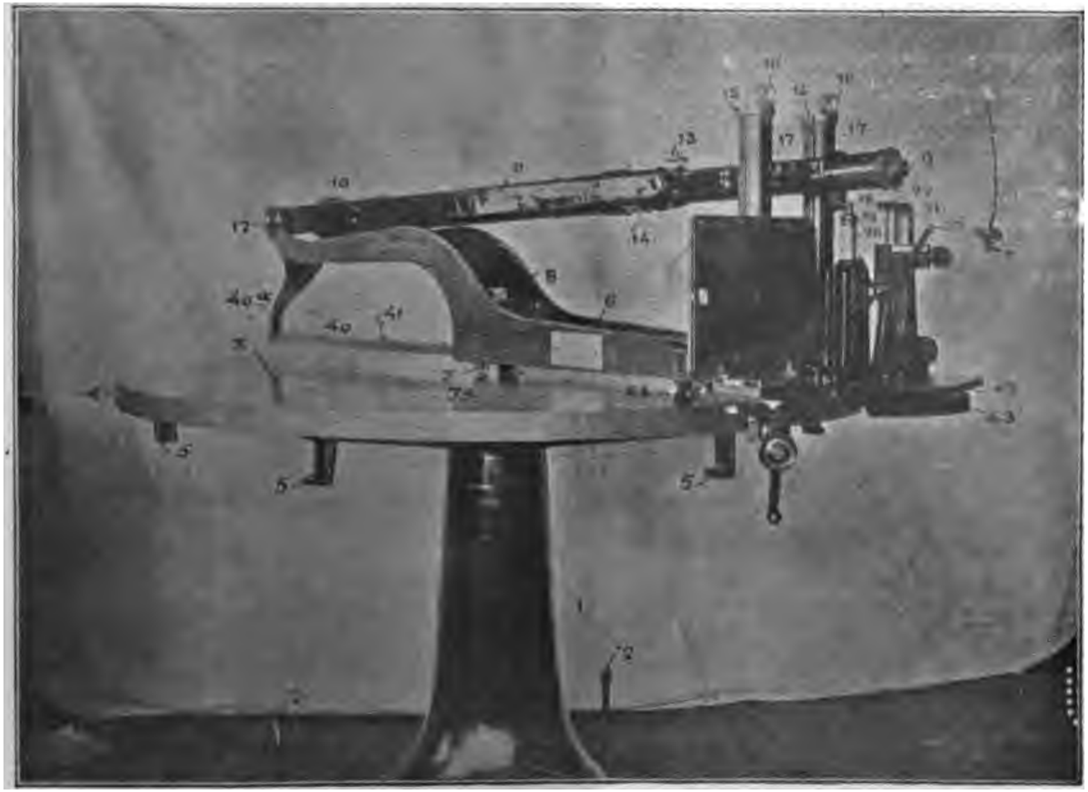

PLATE I.
Side and End View from the Front.

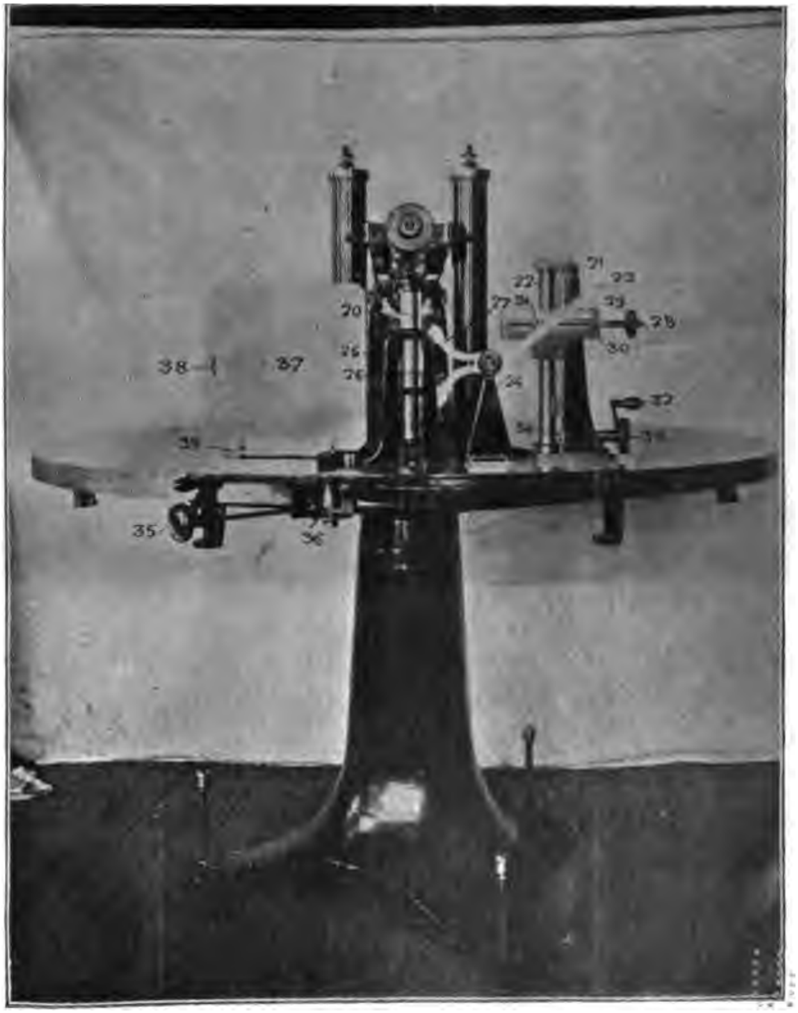

PLATE II.

End View

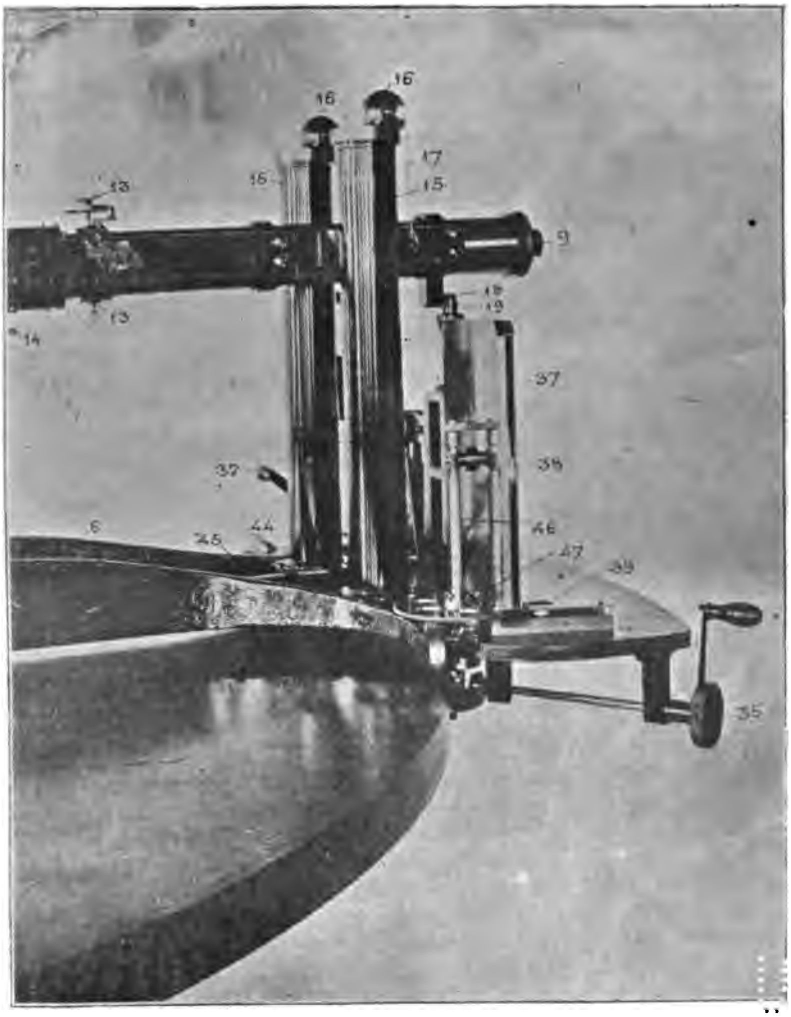

PLATE III.

Partial Side View.

HU

Fifth. *The elevating mechanism*, which consists of the following parts, viz: Elevating screw (22), nut moving thereon; crank (33), and handle (32) which turns the screw by means of the bevel gearing (34); toothed sector (27) and sector arm (23); pivot (31) which is carried transversely along the altitude scale (29) by the small horizontal screw (28); the bracket support for screw (21); bracket support for sector (24); elevating cylinder (20); brackets supporting same (25); toothed rack on cylinder (26); adjustable head to cylinder (19).

Sixth. *The counterweights.* These are contained in two brass columns (15, 15). The weights are suspended from cords (17, 17) which pass over pulleys (16, 16) down through the center of the screw caps on the pillars. These pillars are secured to the top surface of the traversing arm by screws.

Seventh. *The range wheel*, shown as No. 42 in Pl. I. This wheel is 12½ inches in diameter, the gear cut in its circumference being 48 pitch and having 600 teeth. The wheel is mounted on the flat under surface of the traversing arm. The graduation is in black on white celluloid, which is one-sixteenth of an inch thick and set into the metal. The figures show hundreds of yards of range. The scale reads directly to 10 yards, from 1,500 to 6,000 yards, and to 25 yards from 6,000 to 15,000 yards.

A small pinion is carried on the under projection of large elevating screw and meshes with the gear of the range wheel. A cover (43) is fitted over the wheel to protect against dust and accident; the opening in this cover (42) has an index for reading the scale. The gears are very carefully mounted to avoid back lash.

Eighth. *The azimuth device* (37) is shown very fully in the photographs. Degrees are read from the vertical index (38) and minutes are read from the horizontal index (39). Pl. III shows the gearing (47) and vertical worm shaft of this device. A friction roller carried on the vertical shaft rolls on the outer edge of the table, each complete revolution corresponding to 9 degrees of azimuth. Means are provided on the friction roller for moving the shaft and the recording mechanism independently of the roller itself. This enables the operator to quickly correct and set the mechanism to any desired reading without moving the telescope in azimuth.

Ninth. *Means for moving the telescope and arm in azimuth.* This is done by means of a crank (35) which operates a friction roller mounted on the under flat surface of the arm and which rolls around the outer edge of the table. The photographs do not show these parts in detail, but their simplicity is such that no further description is needed.

Tenth. *Spirit level* (45). This is shown in Pl. III, and is used to adjust the level of the table. When in perfect adjustment the arm may be traversed through an entire circle (360 degrees) without changing position of bubble.

INSTRUCTIONS FOR OPERATING THE INSTRUMENT.

It is assumed that a tide gauge, to show the height of the tide in feet above or below mean low tide, has been placed in a position to be readily seen by the observer at the instrument; that one or more datum points have been established whose exact distance and azimuth from the instrument are known; and that the instrument has been set up according to the instructions given herewith.

Before attempting to get the direction and distance of an object, the observer should first see that the table is level; if it is not, he should make it so by means of the three screws (1, 2, 2) in the feet of the instrument, and also by the six small leveling screws in the projecting lugs (5), if such are in use. If the table is level, the arm (6) can complete an entire revolution without displacing the bubble of level (45).

The necessary correction for tide is next made; this is done by reading the tide gauge and making the exact length of vertical base correspond to this condition of tide. To do this, set the index of the elevating pivot (31), by means of the micrometer screw (28), so that the altitude scale (29) will give the exact working base, or distance of the instrument above the water level. This correction should be made at least every hour, oftener if great accuracy is desired.

Under certain atmospheric conditions there will be abnormal refraction; to ascertain if there be such, and to correct for it, first set the range scale (42) to read the distance to an object whose exact range is known. Turn the instrument on the object, and if the horizontal wire does not coincide with the water line of the object, turn the micrometer screw (13) very slightly until it does.

The instrument should be now ready for use. To get the azimuth and range of an object, with the left hand turn the crank to (35) to bring the vertical wire of the instrument on the desired point of the object—the indices (38 and 39) will give the corresponding degrees and minutes of azimuth—at the same time move the crank (32) with the right hand until the horizontal cross-wire cuts the object on the water level; the range can then be read at once from the scale (42).

—*Report of the Chief of Ordnance*, 1896.

FORTIFICATION.

The Latest Ideas on Fortification.

Just as, in all countries, the principles of the construction of fortifications have gradually come to be based on the systematic use of modern war and building materials and means, so, too, in the literature of the subject, those theoretical propositions, which, in their sense of immunity from responsibility the authors have in the past been in the habit of expanding into fantastic illusions and unattainable ideals, have become rarer, and have given place to plans based on thorough practical training and experience, and established by computation and construction.

The fundamental thought common to all authors is this: that an energetic garrison in a well supplied modern fort is in a condition, not only to take up the battle with the attacker with a fair prospect of occasional good results, but also to fully repel the attack, provided it utilizes its means properly, and those of the enemy are not practically inexhaustible. Based on this principle a new era in the history of fortifications has arisen, with the conditions more favorable for the defender than ever existed before.

It is therefore pertinent to ask with Schröter:* "What is the ultimate object of the defense of fortifications?" For, according to the answer to this question, the means are to be applied. "Here are two conceptions possible. One finds the object of the defense to lie in a restistance kept up as long as possible, in *gaining time;* the other in a *victorious repulse of the attack.*" In the first case the defender renounces from the beginning all idea of averting the fate of the fortification through its own inherent strength; with one eye on the abyss behind him and the other looking anxiously for help from without, he will fall back step by step, his track will be a continual series of misfortunes, every day strength and confidence decline, while with every, even partial success, the attacker's strength and confidence grow." In the second case "he does not inquire into the theoretical necessity for the ultimate fall of the fortification," but directs his efforts "towards a tactical result, which may easily become a strategical one ; this result is attained, if not by annihilation, then by weakening or exhausting the power of the attack or the means at its disposal, or at least by preventing the attacker's use of the most effective means of conducting the war for so long a time that he is forced to try an entirely new method, or is even obliged to give up the attack altogether. This aim and purpose of the defender assumes that there will be a grand decisive action," which will require "all available forces and means at the disposal of the defense to take part, *i.e.*, to be posted in a *principal defensive position.*"

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* *Die Festung in der heutigen Kriegführung.* Schröter.

It should be added that if the garrison is defeated in the decisive action it is not in the same unfortunate position as a defeated army in the field, which often leaves the field totally disorganized or annihilated. A tenacious resistance may still be organized out of the remains of the army on the defensive, provided the proper moment, when victory inclines to the side of the adversary and further resistance is useless, is seized, and provided also that the engineering arrangements are such as to facilitate the withdrawal of the forces out of battle, and their reestablishment and application for renewed defensive action.

The object of the defense of fortifications being thus established, Schröter deduces the following as the conditions to be fulfilled in the construction of fortifications:

"1. The most complete and thorough preparation of a principal defensive position, which will permit the use of all the means and forces of the fortification under the most favorable circumstances.

"2. Provision for the organized withdrawal of men and material from this position, and for supporting the continuation of the defense, engergetically and tenaciously, although with reduced strength and means."

The decisive action should not be put off, however, until the attacker has completed his artillery advance into position. Brialmont alone still holds to the principle : " To save ammunition, fire against the batteries of attack will be withheld as long as only small results, in consequence of too great distance, are to be expected." * He quotes Vauban, who advised that the batteries of the second parallel should be attacked first, and places the second artillery position parallel to them. On the contrary, the defense should make every effort possible to take advantage of the difficulties of the attacker's position in the early stages of the attack, and to prevent him, if possible, from carrying out the advance of his artillery to the position selected, and it should also oppose with all its power his strenuous undertaking to establish these batteries in position. But, even after the attacker obtains the upper hand with his artillery, he still has to cross the terrain in front and break through the lines of fortification (the girdle).

In the first stages the principal work falls to the artillery, but even in the short-range stage it is of great value in supporting the infantry, therefore, the first consideration in the organization of a fortified position is the proper selection, posting and utilization of the guns. This is the point about which at present all theoretical discussions revolve.

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* *La défense des côtes et les têtes de pont permanentes.* Brialmont.

THE ARMAMENT OF PERMANENT WORKS.

One of the important elements in the arrangement of permanent works is the essential armament (*Sicherheitsarmirung*) i. e., all those guns which must be in position, fully equipped, when the attacker approaches the fortification. The kind of gun, its caliber and position will be determined by the particular purpose to be fulfilled by it.

All authors are agreed as to the fundamental subdivision of these purposes, viz: (1) long range fire against the enemy's measures at a considerable distance, hence, his preparations for the advance of the artillery to its positions, (2) the execution of the artillery duel, (3) the support and security of the position with intervals, and (4) the repulse of the assault; and, in general, advocate keeping the guns, selected for these several purposes, distinct and separate.

Whether we will be compelled to use for the *long range fire* only 15 cm. horitzers and guns, or can obtain sufficient action from the 12 cm. guns, as is predicted on account of the lighter cover now used by the artillery of the attack, will depend largely on the local conditions, but will not be determined by the smaller cost of the 12 cm. guns which are to be placed in the forts behind armor. Captain Cool* emphasizes the fact that for firing on masses of troops suddenly appearing, especially in mobile batteries, a rapid-fire gun of sufficient power (hence, of medium caliber) is required, and proposes for this purpose a 10 cm. gun; the proposed use by the Austrians of the 75 mm. rapid-fire gun probably tends in the same direction, and has led to the overburdening of the 75 mm. guns in revolving turrets with duties not their own, for they are to serve to repel the assault as well. Colonel v. Scheve† also approves of the 75 mm. caliber, because the guns "are capable of very effective action against troops." He puts them in place of the 17 mm. rapid-fire guns, without, however, stating whether he proposes to use them also for long range fire, or, like Leithner‡ have them take part "in the battle during the enemy's cannonade."

Of great importance, on account of the works which must be constructed in time of peace, is the number of guns regarded as necessary for the work required of the essential armament (*Sicherheitsarmirung*) against long range targets in the first stages of the attack. General v. Brunner is the only one thus far who has undertaken to clear up this question. His demand for at least eight heavy armored guns, or 16 to 20 heavy guns in barbette with shrapnel-proof shields, agrees quite well with Brialmont's measures proposed in the types of his *La défense des Etats* (4 to 6 guns and 4 to 6 pieces for curved fire), and Captain Deguise and Colonel v. Scheve also advocate 4 heavy guns and 4 howitzers. The essential armament (*Sicherheitsarmirung*) proposed by Major Kuk§, on the other hand, appears very weak: he demands "at least two" long-range guns, if they are mounted in the fort, and "at least four", if mounted without armor protection. Lieutenant-colonel v. Leithner furnishes his main works of the girdle with 4 howitzers, or two 15 cm. guns and four 15 cm. mortars, and assumes that these, which "represent a minimum, close on the border of the very least allowable", will be supplemented in completing the armament by other long-range batteries.

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* *De moderne vestingsbouw* ect. Cool, *Militaire Spectator.*

† *Artilleristische Gedanken*, v. Scheve. *Internationale Revue.*

‡ *Ständige Befestigung.* Leithner.

§ *Die Anwendung von beständigen und Feldbefestigungen.* Kuk.

If we take it for granted that, under normal conditions and with medium fort intervals, 8 heavy guns under armor, or 20 without armor, are the proper number for the essential armament (*Sicherheitsarmirung*) of each fort, we come to another question: whether these guns are best mounted in the fort or without.

Deguise*, who is unjustly charged by Kuk with following too closely in the wake of Brialmont, is of opinion that, for the few long-range guns of the essential armament (*Sicherheitsarmirung*) we must make use of armor protection, and also give them the necessary security against direct assault. But since the union of long-range and short-range measures in one work materially simplifies the problem for the enemy, the armored structures are *not* to be placed in the strong points of support of the position. How he solves this problem will appear later, here it is merely a question of principle. Next to him, Schröter† speaks for "*Brialmont* armored forts appropriately modified, without, however, excluding armored batteries in particular cases." He very properly adds that, on account of the tactical and administrative independence which must be given the batteries, the theoretical distinction will probably disappear in practice.

The principal opponents of armored forts are v. Brunner, v. Scheve and Kuk, and they say, with equal force, that the long-range guns are to be mounted in these forts only in case the local conditions are such as to preclude any other way of mounting them, or make it inadvisable. All other authors, however, except the Dutch, admit the necessity for armored forts.

The second question is that relating to the guns working in the intervals, which all authors, with the exception of Brialmont, regard as necessary and mount in casemates (*Traditorenkasematten*). As regards the caliber, kind of gun and number of guns, questions which have until recently been neglected, the views differ greatly. While Kuk, following Leithner, calculates but two guns for each casemate (*Traditoren*) flank, Brunner‡ calls attention to the fact that, to meet an attack in the dark, every part of the terrain lying between forts must be swept by heavy fire, in order to be certain of effective action against troops suddenly appearing and in motion. The number of guns in casemates (*Traditorengeschütze*) increases with the interval and with the unevenness of the ground, and with 2000 m. interval may be taken as at least four guns. Deguise also furnishes his forts with 2000 m. interval with at least four guns on each side, and expects to increase the effect by mounting, besides two 75 mm. rapid-fire guns (which the Austrians also use), two 120 mm. rapid-fire howitzers.

The armament required to secure the points of support of the defense against assault is divided into flank-defense guns and storming guns (*Sturmgeschütze*), the latter designed to support the infantry in its position at the parapet, and of particular importance in case the ditch—without flanking arrangements—has to be swept by fire over the flat slope of the parapet. The number of guns for flank ditch defense is largely a matter of caprice. While, in general, two or three rapid-fire guns are deemed sufficient for sweeping any line, Deguise raises the number to eight guns arranged in two tiers, whereas for frontal sweeping he does not consider it necessary to increase the number of storming guns. For the latter four rapid-fire guns of small caliber, covered with armor, with an equal number of transportable guns under bomb-proofs, are commonly considered sufficient.

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* *La fortification permanente appliquée à l'organisation des fortresses à grand développement.* Deguise.

† *Moderne Festungen und ihre Vertheidigung.* Schröter. *Militär-Wochenblatt.*

‡ *Leitfaden für den Unterricht in der beständigen Befestigung.* v. Brunner, Generalmajor.

In the construction of *armored forts*, therefore, it is a question of mounting 8 heavy guns in 8 (or, by placing the flat-trajectory guns two in a turret, in 6) armored turrets, 4 storming guns in cupolas, besides an armored search-light stand, and at least two armored observation-stands: hence, 13 to 15 armored turrets on the parapet. v. Scheve calls attention to the importance of the last-named turrets, and shows that Brialmont's arrangement of only one turret for both observation and light is not sufficient. The engineer will have to see, therefore, that he never brings two important objects in such relative positions that they are in a common line of fire of the enemy, one behind the other, or at a range favorable for the action of his guns. Colonel v. Scheve shows that Brialmont's plans furnish examples of very objectionable relations, as regards the enemy's fire upon the works, and advances the proposition: "not to neglect, in our altogether too strong desire to obtain an enormous restance capacity by the application of turrets, to place the latter under conditions as difficult as possible for the enemy's artillery fire, and as favorable as possible for our own artillery service." Even Brialmont's new plans in *La défense des côtes etc.*, are not free from this objection, whereas, all other authors strive to unite at least all the heavy turrets in a single front, behind the infantry position over the gorge casemates, an arrangement which appears appropriate as regards the conduct and control of the fire too. Only the storming guns, in Leithner as well as Deguise, lie scattered along the breast-height of the infantry position. This last would have no importance for the heavy turrets, if the infantry position were so far in front of it that the dispersion in range of the mortars could not cover both positions at the same time. However, it is objectionable for the infantry position itself, on account of the fragments of projectiles and stones from the turrets and their beton protection. In this connection the arrangements of General v. Brunner are worthy of attention: he pushes out the turrets of the storming guns in two's, in prolongation of the rows of heavy turrets, in front of the flank superior slopes. If with this is combined a flat three-sided ground plan of the ditch, the storming guns in this position will also have an excellent frontal action.

With his demand for a greater distance between infantry and artillery positions v. Scheve opposes the recent tendency to give forts the minimum depth allowable. He shows that it is useless to count on over shooting, and that the small extent in depth (in Deguise 28 to 50 m. from the front firing line to the gorge firing line, in Leithner 48, in Brunner 33 to 43 m. from the front firing line to the gorge ditch), on the other hand, has only served to allow the dispersion of the projectiles in range to cover the entire depth. He therefore demands an infantry position 60 m. (at least 45 m.) in front of the gun position.

If the heavy guns of the essential armament (*Sicherheitsarmirung*) are mounted in the forts only in part or not at all, permanent batteries for long-range fire are universally regarded as necessary. For these too v. Brunner gives the preference to armored batteries, and holds that in case open batteries are constructed about three times the number of guns will be required. Laying out the batteries as annexes to the forts offers many tactical and economical advantages, and is often necessary in order to utilize favorable points in the terrain, but has the objection of offering an easier target. Isolated batteries require a certain amount of tactical and administrative independence; in other words, they must be surrounded by a work to secure them against capture by assault, and must receive a small infantry support. Because of the greater number (open batteries) required, the cost therefore increases considerably, and it is a question whether the construction of the smaller number of armored batteries required would not be less expensive. It is worthy of note that in Germany, where the more recent forts, as short-range works, are erected without heavy artillery in the type work, there seems to be a tendency to mount the heavy guns of the essential armament (*Sicherheitsarmirung*) partly in annex batteries, partly in armored batteries.*

[Trans. Ed.] *v. Löbell's Jahresberichte*, 1896.

MILITARY GEOGRAPHY.

Notes on a Canadian Journey.

In June and July the writer went from New York to Quebec, to attend the annual convention of the American Society of Civil Engineers, and from Quebec proceeded to Halifax, and thence to Montreal and Chicago, and up to Duluth to attend a meeting of the American Institute of Mining Engineers. The following article contains notes of things seen and information collected during that trip.

QUEBEC.

This is perhaps the most interesting city on the North American continent from an historical and antiquarian point of view, since it is essentially an ancient city which has not been rebuilt and not very much invaded by modern ideas. Here are the old French buildings of massive stone construction, and the language and customs of the "habitans." In the upper town is the great fortress, and the city itself is a walled city, the ramparts extending across the heights of the narrow peninsula upon which the city is built, and having fortified gateways over the three principal streets which extend into the country. The St. Louis gate and Kent gate have been reconstructed on modern plans, and have each a wide single arch over the roadway. The St. John's gate is of older construction, and is of massive masonry pierced by three archways, but this is to be removed in consequence of the obstruction to traffic, and bids for the work have recently been received by Mr. Charles Baillairge, the City Engineer. The garrison is composed of colonial troops.

QUEBEC HARBOR.

The city is a seaport of some prominence, having an extensive river and coasting trade, while ocean steamers also sail from here, and nearly all the ocean mail steamers to and from Montreal make Quebec a port of call. During 1896 there were 356 vessels entered inward and 294 outward, the imports amounting to $4,013,903 and the exports to $5,411,418.

The principal artificial works of the harbor are those of the Princess Louise docks and embankment, opened in May, 1890. As shown by the accompanying plan, these works are situated at the junction of the St. Charles and St. Lawrence rivers. The outer or tidal basin has an area of about 20 acres, and a general depth of 26 to 27 feet at low tide, with a quay frontage of 2,860 feet. Along the face of the embankment quay there is a depth of 24 feet of water, but a vessel lying 10 feet from the quay can have a depth of 26 feet of water. Spring tides rise 18 feet and neap tides 12 feet, the average rise of tides being 15 feet, but as the tide rarely falls to within 1½ feet of the low water datum, the depth of water in the tidal basin is virtually greater than that given above. The inner dock, or wet dock, has a water area of about 40 acres, a general

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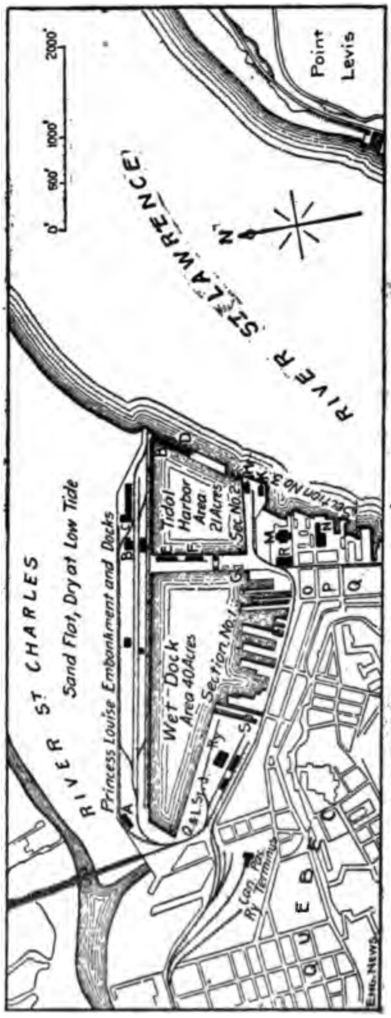
* *Hilfsbuch für den Pionierunteroffizier.*



MAP OF QUEBEC HARBOR AND PRINCESS LOUISE DOCKS. (A) Coal-oil store. (B) Grain elevator. (C) Immigration building. (D) Disinfecting building. (E and F) Freight sheds. (H) Warehouses. (K) Cold store. (M) Custom house. (R) Harbor Commissioners' offices. (N) G. T. Railway. (O) Bank of Montreal. (P) Bank of B.N. America. (Q) Quebec Bank. (S) Q. & L. St. J., Q.M. & C., and B. L. Railways.

depth of water of 27 feet, and a quay frontage of 3700 feet. The dock gates are opened twice in 24 hours, for a period of about two hours eac time. The entrance lock i 66 feet wide, and is closed by a set of timber miter gates, the depth of water on the sill being 18 feet at low tide, and about 29 feet at high water of neap tides. The entrance is crossed by a steel highway bridge, which runs back and forth on two double tracks, the time for operating or closing being about 45 seconds. It is operated by steam. The embankment is about 4000 feet long and 330 feet wide, and the cross wall 800 feet long and 150 feet wide. On the embankment are railway tracks connecting with the several railways entering Quebec. The quay walls of the dock, below low water, consist of crib work, the front pockets of which are filled with concrete laid in a plastic state. The superstructure is in some cases entirely of masonry, while in others it is of concrete with a facing of cut stone.

The docks are provided with grain elevators, freight sheds, and a cold storage building, the cold dry air circulation system being used. No coal is loaded at these docks, but a large quantity, both of hard and soft coal, is received, special portions of the embankment being set aside for coal cargoes.

The works now under construction and contemplated consist of completing the quay walls along the south side of the wet dock and tidal harbor; the construction of a quay wall 1100 feet long along the river front, from the Point-a-Carcy wharf in a southerly direction; the construction of a graving dock about 700 feet long, and the erection of double-deck freight sheds provided with hydraulic or electric wharf cranes and other freight handling machinery. The quay walls under construction and contemplated are shown by heavy dotted lines on the accompanying plan, Fig. 1, and are marked Sections 1, 2 and 3.

A new graving dock or dry dock on the Quebec side of the river is proposed, and the site suggested for this dock is at Point-a-Pijean, about three miles south of the eatrance to the Louise Docks. The dock is to be 700 feet long, with an entrance 80 feet wide, and a depth of water of 28 feet on the sill at average high tide.

Opposite Quebec is Levis, or Point Levis, where are situated the stations and yards of the Intercolonial and Grand Trunk railways, a stone dry dock, and the works of Carrier, Laine & Co., manufacturers of dredging plant, cranes and other machinery.

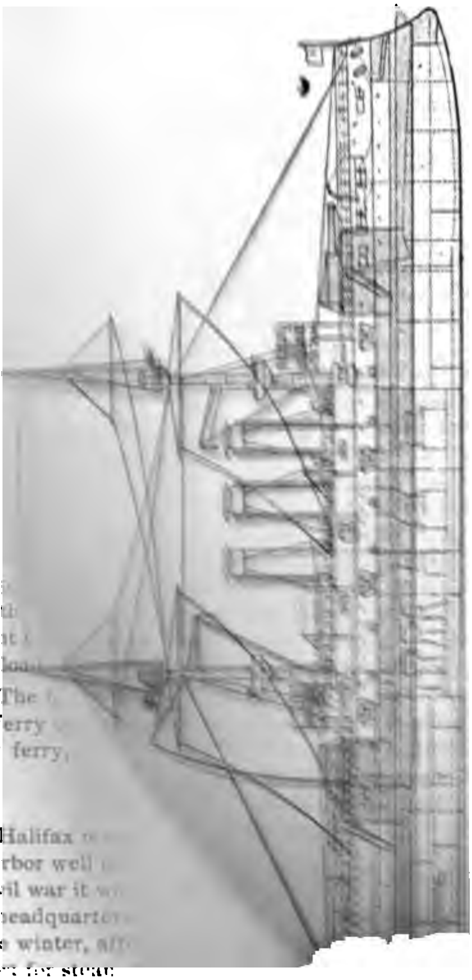
The dry dock or graving dock at Point Lewis is constructed of masonry and Portland cement concrete. It is rectangular with a semicircular head of 31 feet radius, the total length from caisson to circular head being 484 feet. The entrance is closed by a caisson which moves on rollers and is withdrawn into a covered recess when the dock is being opened.

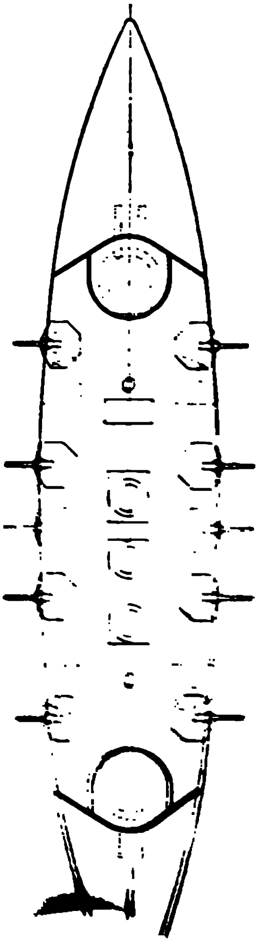
RAILWAYS OF QUEBEC.

The Province of Quebec has a number of railways, of which the following are the most important:

(1). The Canadian Pacific Ry.; this has a line on the north side of the river from Montreal to Quebec, 172 miles, and a line from Montreal to St. John, N. B., 481 miles, which latter line cuts diagonally across the Province and crosses the state of Maine. (2). Grand Trunk Ry.; this has a line from Montreal along the south shore to Levis, opposite Quebec, 173 miles. The Halifax sleeping cars of the Intercolonial Ry. are hauled to and from Montreal over this line. There is also the main line south from Montreal to Portland, Me., 297 miles. (3). Intercolonial Ry.; this is the line built and owned by the Dominion Government, and extends from Levis to Halifax, 678 miles.. Some notes on each of these three lines will be found farther on. (4). Quebec Central Ry.; this extends from Levis, opposite Quebec, to Sherbrooke, 143 miles, and gives through connections fo New York and points in New England. (5). Drummond County Ry.; the main line now extends from Ste. Rosalie Junction (Grand Trunk Ry. and Canadian Pacific Ry.) to Forestdale, 66 miles, but an extension of 43 miles is now under construction from Forestdale, the present terminus, eastward to Chaudiere Junction, at which latter point it will connect with the Intercolonial Ry., Quebec Central Ry. and Grand Trunk Ry. Ste. Rosalie is 38 miles from Montreal and access to that city is obtained by running over the Atlantic Division of the Grand Trunk Ry., from St. Hyacinthe. The new line is already connected with the I. C. Ry. and G. T. Ry. at Chaudiere, and track is being laid from both ends and from the middle of the line, material being taken down over the Lotbiniere & Megantic Ry., which extends from Lyster on the G. T. Ry., north to St. Jean on the St. Lawrence River, and which is crossed by the new extension. The construction of this extension was commenced last spring and is expected to be completed by November, 1897. (6). Quebec and Lake St. John Ry.; this line extends from Quebec north to the hunting and fishing regions and the summer resorts at the head of the Saguenay River. At the upper end the line forks, one part going to Roberval, 190 miles, where there is a large hotel, and the other going down the river to Chicoutimi, 228 miles, where connection is made with the Quebec steamers of the Richelieu & Ontario Navagation Co., so that a round trip by rail and boat may be effected. The Quebec end of this line, and the Lower Laurentian Ry., which branches off from it (and is leased by the Q. &

[illegible] as follows: An armor belt, 2.5 m. wide, of 228 mm. greatest thickness amidships tapering to 101 mm. at the ship's ends, surmounted by secondary belt, reaching up to the main deck, 76 m. long, 152 mm. thick, at the [illegible] of which stand the barbette turrets. Armored bulkheads 354 mm. thick, [illegible] from the armored deck to the main deck close in the side armor, and [illegible] with it an armored citadel 76 m. long. The barbette turrets rise from [illegible] to a height of 1.2 m. over the upper deck. An arched armored [illegible] running the entire length of the ship rises from the deeper parts of the





Neues japanisches Schlachtschiff I. Cl.

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DOMINION ATLANTIC RAILWAY.

This line extends from Halifax across Nova Scotia to Digby (where steamer connection is made for St. John, N. B.) and then westward along the coast to Yarmouth, where connection is made with steamer lines to Boston. At Digby the train runs out on a pier alongside the company's fast side wheel steamer "Prince Rupert" for St. John, crossing the Bay of Fundy, with its 60 foot tides. Owing to the great height of the tides (40 to 60 feet) the water pours in through Digby Gut, the narrow entrance to the land-locked harbor, like a rapid, the water boiling up as it does in the still water between the falls and the rapids at Niagara.

CANADIAN PACIFIC RAILWAY.

This railway has now its own line from the Atlantic port of St. John, N. B., to the Pacific port of Vancouver, B. C., with a main line mileage of 3,387 miles. The line from St. John to Montreal, 481 miles, is partly over the old New Brunswick Government Ry., then over a part of the Maine Central R.R. (to Mattawamkeag), and then over the company's own line, passing through a wild country of lakes, woods and mountains until it reaches the flat country of the south shore of the St. Lawrence. It crosses that river by the great Lachine Bridge, which has two channel spans of 408 feet, with through trusses, the rest of the bridge being composed of deck spans. The long trestle approach on the south side has now been almost entirely replaced with a solid bank, and on the north side three masonry arches are being constructed under the railway preparatory to filling in the bank.

In leaving St. John the railway crosses the St. John river by a cantilever bridge having through trusses. The river here pours through a rocky gorge only about 500 feet wide, and at low tide it has a fall of about 15 to 20 feet at the mouth of the gorge. At high tide, however, the fall is reversed, and the water from the Bay of Fundy pours into the river with a fall of about 15 feet.

The Canadian Pacific Ry. has always taken the aggressive against the Grand Trunk Ry., and has invaded all the latter's territory. It has gone down to New England and the eastern provinces, has acquired the parallel line to Ottawa which the Grand Trunk Ry. so much desired, and has extended on to Windsor to connect with the Wabash R. R. at Detroit for a through route from Montreal and Toronto to Chicago, 863 miles, thus competing with the through route of the Grand Trunk Ry. and the Chicago & Grand Trunk Ry. This route was opened in 1893.

Between Windsor, Ont., and Detroit, Mich., the trains are carried across the Detroit River by side-wheel steam ferry-boats or car transfer boats.

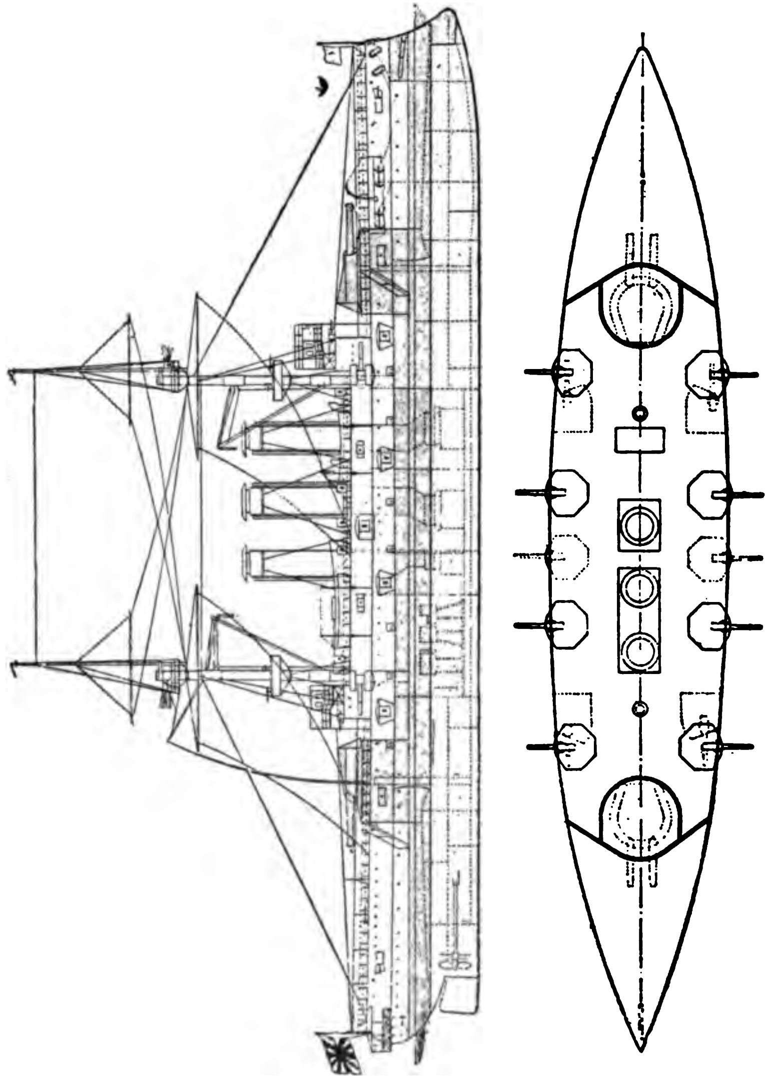
—*Engineering News*, August 26, 1897.

War-Ships and Torpedo Boats.

Japan.

The contract for the construction of a new battleship was closed on February 4th with the "*Thames Ironworks and Shipbuilding Co.*" This ship is to be 121.9 m. between perpendiculars, 133.5 m. maximum length, 23 m. beam and 8.3 m. draught, with a displacement of 14850 tons. If, in comparing this vessel with the ships of the Majestic class, we neglect the coal carried, the hull, including machinery, armament etc., displaces 150 tons more than these greatest of battleships of today.

This new battleship is to have throughout Harveyed plates for protection, distributed as follows: An armor belt, 2.5 m. wide, of 228 mm. greatest thickness amidships tapering to 101 mm. at the ship's ends, surmounted by second (side) belt, reaching up to the main deck, 76 m. long, 152 mm. thick, at the ends of which stand the barbette turrets. Armored bulkheads 354 mm. thick, reaching from the armored deck to the main deck close in the side armor, and form with it an armored citadel 76 m. long. The barbette turrets rise from the main deck to a height of 1.2 m. over the upper deck. An arched armored deck running the entire length of the ship rises from the deeper parts of the armor belt amidships to 0.9 m. over the water line and is in its level parts 76 mm. thick, in the inclined parts 126 mm.



Neues Japanisches Schlachtschiff 1. Cl.

Each barbette is to carry two 30.5 cm. guns, 40 calibers long, and in armored casemates 152 mm. thick are to be installed fourteen 15 cm. rapid-fire guns. There are eight such casemates on the main deck, six on the upper deck. These casemates are capable of being closed watertight. Besides, the new ship is to have twenty 7.5 cm. and twelve 4.7 cm. rapid-fire guns on the main and upper decks, and five torpedo tubes, one above water (in the bow) and four below water (broadside).

The vessel is to have a speed of 18 knots. It is to possess 14 boats in all, including two steam launches (*Vedetteboote*). The latter, as well as two other steam launches will be provided with *Whitehead* torpedoes and the necessary apparatus. The complement comprises 741 men. The ship is to be completed in 23 months.

Mittheilungen aus dem Gebiete des Seewesens, No. VI, 1897.

The Torpedo-boat Destroyers of 30 knots.

The ship-yard of Laird Brothers, Birkenhead, the rivals of Yarrow and Thornycroft in the building of torpedo boats and torpedo-boat destroyers started in this difficult branch of naval art with the famous *Rattlesnake*. This boat, built in 1887, made 20 knots, a high speed for that time, its displacement being 550 tons. It may be considered as the first boat built to destroy the torpedo boats, as the prototype of the destroyers. After completing the *Rattlesnake* Laird Brothers undertook the construction of a certain number of similar boats for various South American states. From their yards came the *Lynch* and the *Condell*, which played such an important rôle in the last war between Chili and Peru. Then came the *Onyx* and the *Fox* for the English government, followed by the five destroyers of 27 knots of the *Ferret* type, and finally the class of destroyers of 30 knots. Four of these last have been delivered to the Admiralty, the *Quail*, *Sparrowhawk*, *Thrasher* and *Virago*, and four others have been made for Chili. Six destroyers of 30 knots and one of 33 are being completed.

The sixteen English destroyers built by Laird Brothers are identical in hull, armament and machinery. They are 64 meters long, 6.5 meters beam, 3.8 meters draught, 300 tons displacement. They carry coal sufficient to enable them to go 3500 miles at 13 knots.

Their armament consists of a 12-pounder rapid-fire gun, 5 6-pounder rapid-fire guns, and two torpedo tubes. Their complement is 65 men.

Le Yacht, June 5, 1897.

BOOK REVIEWS.

The Life of Nelson, the embodiment of the Sea Power of Great Britain, by Captain A. T. Mahan, D. C. L., LL. D., United States Navy. Boston: Little, Brown & Co., 1897. Two volumes; 8vo Cloth, gilt top. Price: $8.00.

The life of Nelson naturally and appropriately rounds off and concludes Captain Mahan's series of articles on *sea power*, for in that greatest of naval captains is embodied the highest that that term comprehends. The sea power of Great Britain it was that drew the magic circle which limited Napoleon's sphere of action and finally crushed him, and Nelson was the man above all others who wielded that power and was the great soldier's great antagonist. Bonaparte's dreams of eastern empire, opened so splendidly with the campaign in Egypt, were cruelly dissipated at Aboukir; his efforts to weaken the power of Great Britain, through the destruction of her commerce, by causing the renewal of the Armed Neutrality, were signally defeated at Copenhagen, and finally his designs on England herself by direct invasion were hopelessly crushed at Trafalgar.

But, while illustrating the importance of sea power on so grand a scale, the charm of the work lies in the life it portrays so faithfully. It adds another to that delightful class of literary works designated as *memoirs*, and takes high rank among them. It makes us intimately acquainted with a remarkable man, the world's greatest sea-fighter. When we close the book we feel that we know this man. There is no doubt about his weaknesses, his irritability, his insubordination, and yet we admire and love him. The portrait is true to the life, his faults and his virtues are presented with equal fidelity, but there is no mistaking the lesson to be learned from either,—and in the manner in which this is accomplished is reflected the author's own character.

The thought that above all others forces itself upon the mind in the perusal of this work is this, that genius, however great, avails nothing unless brought into action by persevering effort.

Born in 1758, Nelson began his life at sea at the age of twelve, when he was taken on board his uncle's ship, the *Raissonable*. He made several voyages, on merchantmen and naval ships, doing the duties of a sailor aloft, to the West Indies, the East Indies and on the North Pole expedition, and in 1776 he served for six months as acting lieutenant on the *Worcester*, engaged in convoy duty between the Channel and Gibralter. In 1777 he received his commission and entered service on the *Lowestoffe* in the West Indies, where he remained until 1780, having been meanwhile promoted to captain, at the age of 21. He returned to England on account of ill health, but the following year finds him again on convoy duty, first in the channel and later at Quebec. In 1782 he was transferred to Lord Hood's fleet, and returned with it at the close of the war in 1783.

He was now twenty-five, and although he had accomplished little in direct achievement, his reputation as a capable officer was established. Hood said of him that he "knew as much about naval tactics as any officer in the fleet."

In 1784 he was appointed to command the *Boreas* and in his service in the West Indies his two great qualities, strict attention to duty and fearlessness in assuming responsibility, came prominently into evidence. During this cruise he met at Nevis the lady who, in 1787, became his wife, and three months er he sailed for England, where he lived in retirement till 1793.

His career in history begins with 1793 when he took command of the *Agamemnon*, and joined the Mediterranean squadron. His active and restless spirit, as well as his recognized ability, caused him to be selected for delicate detached service over many of his seniors. It was largely through his personal efforts that Corsica was reduced by the British, and there in the land attack on Calvi, Nelson lost the use of one of his eyes from the sand driven into it by a ricochet shot. "Corsica has cost me £300, an eye, and a cut across my back," he said in summing up, after the island fell.

The action with the *Ca Ira* (1795) illustrates well some elements of his character. Hotham's fleet had sighted the French and gave chase. The *Agamemnon*, well to the westward from the start, soon saw an opportunity to attack the *Ca Ira*, an eighty-gun ship, "absolutely large enough to take *Agamemnon* in her hold," Nelson said, and disabled her so as to cause the next day's battle, because the French either had to fight for her or abandon her.

"In this affair, what is mainly to be noted in Nelson is not the personal courage, nor yet even the professional daring, or the skill which justified the daring. * * * What is rather striking, account for it how we will, is that Nelson, here as always, was on hand when opportunity offered; that after three days of chase he, and he only, was so far to the front as to be able to snatch the fleeting moment."

The action of the following day was only partial, although Nelson went on board Admiral Hotham and tried to persuade him to pursue. His comment on the admiral's reply that "we have done very well" is characteristic: "Now, had we taken ten sail, and had allowed the eleventh to escape, when it had been possible to have got at her, I could never have called it well done."

In July, 1795, Nelson was despatched to command a detached squadron on the Riviera in cooperation with the Austrians, and on that station he did excellent service in intercepting contraband trade. Nelson's active mind, however, would not permit him to rest in the simple discharge of his duty: he was continually planning operations to assist the Austrians and their allies on shore, but he was not encouraged by the admiral. Although the campaign ended ignominiously for the British, "Nelson's own reputation issued from it not only unscathed, but heightened." He remained in service on that station until the end of 1796, when the British abandoned the Mediterranean, having meanwhile been promoted to Commodore. Upon reaching Gibralter Nelson was sent back to effect the evacuation of Elba, and on his way had a night combat with two Spanish ships.

Upon joining the fleet again west of Cape St. Vincent, the Spanish fleet was sighted running for Cadiz and a battle ensued in which Nelson, by disobeying the admiral's (Jervis') orders, brought about a great victory. "In the evening, while talking over the events of the day, Calder spoke of Nelson's wearing out of the line as an unauthorized departure from the method of attack prescribed by the admiral. 'It certainly was so,' replied Jervis, 'and if ever you commit such a breach of orders, I will forgive you also.'" His energy in fighting his ship for all she was capable of is shown by the fact that her loss in killed was double that of any other ship and in killed and wounded nearly one-third that of the whole fleet. She had lost her foretopmast, not a sail, shroud, or rope was left, her wheel shot away, and she was incapable of further service in the line, when he put her helm a-starboard and called for the boarders. He was made a Knight of the Bath for his distinguished conduct in this brilliant victory, and by a flag-promotion soon after became a Rea Admiral of the Blue at the age of thirty-eight.

Nelson's active mind again suggested an expedition: this time agai Teneriffe, where it was feared the enemy's treasure-ship from Mexico, warne of their danger from the British fleet, might take refuge. Nelson, of course led the land attack in person, and came near losing his life. He was struc by a grapeshot in the right elbow, so that the arm had to be amputated, an he was invalided home.

In April, 1798, he again joined the fleet off Cadiz, and was at once sent t the Mediterranean to watch the French fleet at Toulon. His long chase whic ended in the battle of the Nile is but another illustration of his endurance, patience, perseverence and sound judgment in difficult situations. In the battle itself Nelson's preparedness of mind as well as of purpose, his fertility of resource and quick perception, his full grasp of the situation, all combined to bring about his first great victory. All the vessels of the French fleet except two were either taken or destroyed.

His next service was at Naples and Palermo, where he combined much diplomatic work with his ordinary duties. It was at Naples that he first fell under the influence of Lady Hamilton, the story of whose relations with him is told with wonderful delicacy.

In 1800 he returned to England on leave, and in 1801 hoisted his flag in the channel fleet, under Lord St. Vincent. War breaking out with the Triple Alliance he was sent to Denmark with the fleet of Sir Hyde Parker. His impatience at Parker's slowness, his tact and discretion in his dealings with him, the accuracy of his judgment of the conditions and the adoption of his plans of attack on Copenhagen all serve to illustrate his character and genius. Parker gave Nelson twelve ships-of-the-line with which to conduct the attack. In the midst of the fight, while Nelson's ships were all engaged under heavy fire, Parker, whose fleet was about four miles off, made the signal to leave off action. Nelson ackowledged it but kept up his own signal for close action. The result was a complete victory and the destruction of the defenses of Copenhagen.

After his return to England he commanded the squadron on a particular service for the defense of the coast against invasion, and when the preliminaries of peace with France were signed he retired to his new home at Merton.

In May, 1803, he returned to the Mediterranean as commander-in-chief, and began his long watch of the French fleet off Toulon. The escape and pursuit of the Toulon fleet, and Nelson's return to England disappointed in his desire to overtake it are told with keen interest. In every action his one desire was to close with the enemy, his despatches to the Admiralty usually assured them he and the enemy would not part without a fight, his fear of the enemy eluding him was greater than that of a conflict with superior numbers, he was always in position to take advantage of whatever opportunity offered, and his genius and the inspiration of the moment determined the best method and the proper time for action. In his orders for the battle of Trafalgar he says: "But, in case Signals can neither be seen or perfectly understood, no Captain can do very wrong if he places his Ship alongside that of an enemy."

On October 21st, 1805, Nelson established at Trafalgar the decisive supremacy of Great Britain's sea-power, and closed his career in the hour of his triumph in death.

The interest of these delightful volumes is greatly enhanced by the fact that the author's thorough acquaintance with naval strategy and tactics enables him to present Nelson's plans of action in clear, incisive language, that brings their strong points boldly into prominence.

The handsome volumes are adorned with nineteen portraits and plates in photogravure, and illustrated with twenty-one maps and battle plans.

J. P. W.

Napoléon Bonaparte et les Généraux Du Teil (1788—1794). Par le Baron Du Teil. Paris : Alphonse Picard et Fils, Editeurs. Pp. 193.

The two generals Du Teil were intimately connected with the early history of Napoleon, one commanding the artillery school of Auxonne in 1779, the other commanding the artillery of the army before Toulon in 1793.

The work of Baron Du Teil opens with an interesting account of the first artillery schools in France to the founding of that at Auxonne in 1759. The character of the Auxonne school is fully described, and from the time when Colonel Du Teil became commandant the book assumes somewhat the character of *memoirs*.

"On the 19th of December, 1787, the last of the regiments, which the Baron Du Teil was called upon to direct the instruction of, as commandant of the school, entered Auxonne. It was the regiment La Fère, commanded by the Chevalier de La Lance; the company of bombardiers, which came from Havre, and in which, as second lieutenant, was "Napolionne de Buonaparte," joined on the 25th of December."

Napoleon was absent, and did not personally join till June 1788. On his arrival he was lodged in one of the rooms reserved for the lieutenants, about fifteen feet square, to which was attached a servant's room, about eleven feet square. The list of the furniture of these rooms shows how simple must have been the life of the future emperor at this time.

The state of the school in 1780 and the changes introduced from 1781 to 1789, as well as the experiments carried on, in some of which Napoleon took a prominent part, are set forth. It is evident from the fragments remaining, meager as the are, that Napoleon at this time was interested in his profession, and his estimate of his commandant, General Du Teil, as "an excellent artillery officer," rather goes to prove this also.

The commandant seems to have taken an interest in Napoleon, for in September, 1789, we find them leaving Auxonne on leave together and traveling in company as far as Lyons; and the colonel of the regiment seems to have shared this interest for we find him antedating Napoleon's return to the garrison in order to cover part of his absence beyond the limits of his leave, and asking that the money stopped against him for the remainder be refunded.

In the reorganization of the artillery Napoleon was transferred to the 4th regiment then at Valence. His former school commandant, Baron Du Teil, was made inspector general of artillery of the department of Grenoble, which included the school of Valence. Napoleon preserved his influence with his commandant, who seems to have recognized the military genius of his young subordinate.

In 1793 brigadier general Du Teil (brother of Baron Du Teil) was assigned to the command of the artillery of the Army of Italy.

"The commandant of the artillery of the Army of Italy soon found an active collaborator in Bonaparte, whose reputation had long been known to him as he was under his elder brother's orders from June 1st, 1788, to August 30, 1791. Napoleon, who was in Corsica since the autumn of 1792, arrived in

Nice at the end of June, 1793, and was at once assigned by General Du Teil to the most important service under his direction, that of the coast batteries."

While awaiting the confirmation of his appointment Napoleon was charged with conducting a convoy of powder to Avignon. At Pontet he met the Army of the South, and it appears that he joined the flying column against Avignon, and resumed his mission only after its fall. His request to be transferred to the Army of the Rhine called forth Bouchotte's recommendation: "If he has talents, let us profit by them in promoting him."

After the fall of Avignon Napoleon kept in touch with the Army of the South. Saliceti, in a letter to the Committee of Public Safety of September 26 says: "Dommartin wounded has left us without a chief of artillery. Chance came to our aid: we stopped citizen Buonaparte, a well-instructed captain on his way to the Army of Italy, and ordered him to replace Dommartin."

The siege of Toulon and the part taken by Napoleon and Du Teil is described in detail and an interesting chapter in the early life of the great strategist is here furnished.

This history, throwing as it does additional light on the early life of Napoleon, is of considerable interest. To Americans the author is brought somewhat closer by the fact that his grand uncle, Michel Du Teil, served as an officer in the campagnes in America from 1780 to 1783, and to the Artillery by the fact that he himself is now an artillery officer.

The volume is printed on heavy paper and embelished with portraits, autograph documents and a plan of Toulon engraved by William Faden, Charing Cross, in May 1794. J. P. W.

Military Handbook by Major H. C. Groome, Assistant Adjutant General, First Brigade, N. G. P. One volume, 8vo, pp. 273. Philadelphia: Hallowell Co., Ltd. $1.50.

A really good book, valuable not only for its treatment of the material selected, but also on account of the judgment exercised in the selection of this material. It is difficult to see how any officer of the National Guard (particularly of Pennsylvania) can afford to be without this compilation, as it gives him in small compass all that he requires for his ordinary duties, besides furnishing him the essential part of his preparation for the field.

Part I relates to the military establishment of the State of Pennsylvania and the laws governing it. Part II treats of organization, instruction, interior economy etc., and contains a clear, brief and most useful treatise on official books and papers. Part III give the necessary information in regard to Ceremonies, Flags and Medals. Part IV contains valuable notes on infantry fire, the space and time required in formations and marches, military signalling and military field engineering, and comprises an excellent article on that most important subject in the field: military topography and sketching. Part V concludes the work with articles on riot service, the articles of war and miscellaneous matter.

The material is taken from the best available authorities, and is arranged systematically and set forth clearly.

"The author undertook the preparation of this book with the hope of being able to place at the disposal of the officers and enlisted men of the National Guard of Pennsylvania a compendium of information on certain subjects, a knowledge of which would facilitate the performance of the routine duties of the Guard and possibly create a desire for further research." (Author's Preface).

Major Groome may well be satisfied with his good work. It has met with the approval of his Division Commander, Major General George R. Snowden, who took a deep interest in its preparation, and has been adopted by the Governor of the state "for the guidance and instruction of the National Guard of Pennsylvania in all matters not otherwise prescribed, by competent authority."

The dress of the book is neat and appropriate and makes it in every sense a useful and valuable *handbook*. J. P. W.

The Naval Annual, 1897. Edited by T. A. Brassey. Portsmouth: J. Griffin & Co., 2, The Hard. Pp. 438.

The latest issue of this important publication is quite equal to the past issues. The number of illustrations has been increased to eleven, and special attention is directed to the re-classification of battleships and first-class cruisers.

The volume opens with an account of the progress of the British Navy in the past year, followed by that of foreign navies. The chapter comparing the strength of the navies of the world opens with the statement:

"No year since the *Naval Annual* was first published has been so full of anxiety for those at the helm of the British Empire, in no year has there been such imminent danger of war, as in the one just passed away. * * * In former years we used to confine the comparisons made in this chapter to the fleets of France and Russia; but during the past year it has become more and more evident that we must take into consideration the Navies of all the principal Naval Powers." And we find the United States one of the six in the table of effective fighting ships. Further on we find: "The people of the United States seems to be determined to take a position amongst the Naval Powers of the world. Though Congress did not accede to all the demands of the Secretary of the Navy, it authorized the construction of some powerful ships in addition to those already building. By the end of the century the United States will posses a fleet of some eight first-class battle-ships.

An excellent account of the German Navy is furnished by Korvetten Kapitan Ferber.

The article on the Attack of Ships by Artillery Fire contains comparisons of great interest and practical value. In discussing the significance of the rectangles (given in last year's issue), whose areas were proportional to the energy of fire per minute by all the guns of various classes of ships, the author remarks:

"It was never intended that a ship's fighting powers, or even her fire, should be considered to be truly measured by these retangles. They showed, however, a very important element of power. With ships possessing equal provisions for using their guns, probably a fair comparison might be made, though it need hardly be said that such a comparison must fail between two ships so placed that one can use a much larger proportion of her guns than the other. The figures shown, however, are, in some cases, such that overhelming advantages would be needed to neutralize a difference brought out by calculating the energy of fire per minute, although little suspected until this test was applied. For example, the United States cruiser *New York*, of 8500 tons displacement, might naturally be expected to be a match for the Chilian cruiser *Esmeralda*, of 7000 tons; but if their total energies of fire per minute be calculated, the *New York* only delivers 119,904 ft.-tons against the 509,091 ft.-tons of the *Esmeralda*. A difference so startling as this surely has a very practical bearing." The *Renown* and *Jauréguiberry* are compared in attacking and defensive powers, also the *Kearsarge* and *Tria Sviatitelia.*

The paper on the Principles of Imperial Defense is replete with interest. The main argument, of course, is to show that the defense of the Empire rests absolutely on power to retain the command of the sea, and it will have to meet attacks on commerce, attacks on colonies, and, possibly, invasion. "The United States, it is true, were the first to lay down the type of fast and lightly armed cruiser, represented by the *Columbia* and *Minneapolis*, which have a trial speed of close on 23 knots. * * * France has followed suit by laying down this year two cruisers of the same class, the *Guichen* and *Châteaurenault*. We can only judge whether the policy indicated by the construction of such ships is likely to be successful in the future by the experience of the past. * * * In commenting on the results of the war of 1778, Captain Mahan says: 'Especially is commerce-destroying misleading, when the nation against whom it is to be directed possesses, as Great Britain did, and does, the two requisites of a strong sea-power—a wide-spread, healthy commerce and a powerful Navy. Only by military command of the sea, by prolonged control of the strategic centres of commerce, can such attack be fatal.' * * *

"Canada and India alone of British possessions are open to serious attack by land. * * * The contingency of war with the United States no Englishman likes to contemplate. Should Canada ever again be liable to invasion, our power to defend Canada depends, as in the case of India, on the power of transporting British troops by sea. * * *

"If for the protection of our commerce, our colonies, and our coaling stations, we depend in a great measure on our Navy, still more do we do so for defense against invasion." In connection with this discussion it would be well to read Major-General Maurice's recent work entitled "National Defenses," from which we quote following (referring to Captain Mahan's Life of Nelson):

"To anybody who reads between the lines it is clear from his narrative that the possession of Corsica and subsequently of Sicily, as well as the defense of Acre, Abercromby's victory at Aboukir, the capture of Copenhagen, the seizure of the West Indian Islands, all of which were the achievements of land forces, transported under the protection of the Navy, were essential to the effective carrying out of the policy which he shows to have been so powerful."

We are convinced that the future will see the United States a great naval power, and therefore the study of England's history and England's plans constitute our most valuable aids to correct ideas on the subject. Captain Mahan has completed his labors on the sea power of Great Britain in the past, let him round off his work with an account of the future sea-power of the United States.

The *Annual* contains the usual tables of the ships of the different nations, all prepared with great care from the most reliable data obtainable. In spite of many points in the essays, which are open to discussion, it becomes each year more and more essential to the Naval officer as well as to the officer of sea-coast Artillery. J. P. W.

Root's Military Topography and Sketching, prepared for use in the United States Infantry and Cavalry School. Second Edition, revised and enlarged by the Department of Engineering. Kansas City, Mo.: Hudson-Kimberly Publishing Co. $2.50.

This work is, for the purposes of our service, the best in existence today.

We say this advisedly, fully appreciating the value of its many excellent English competitors. In scope, arrangement and treatment it surpasses all that we have examined.

The method adopted in the treatment of the subject is sound in principle, viz: "first examining the principles upon which large surveys are made and the instruments and methods used, in which every care is taken to obtain accurate work, before dealing with the more rapid and necessarily less accurate sketches executed for military or other purposes of a temporary character." The only way to learn to *sketch* accurately is to first use instruments and take measurements.

Part I, Topographical Surveying, contains the more accurate methods with instruments of precision, Part II, Topographical Sketching, the cruder methods using instruments for rapid work only.

The instrument of greatest accuracy and most general use selected for description is the Engineer's Transit; for less accurate measurements horizontally, the Compass, Plane Table and Sextant, vertically, the Sextant, Y-Level and Aneroid Barometer.

The instruments described for use in sketching are the telemeters, odometers, cyclometers and pedometers, the box and prismatic compasses and the Abney level and clinometer.

The chapters on methods of field work and military reconnaissance are excellent and leave nothing to be desired.

The book is fully illustrated, and the tables in the Appendix show that it is the work of practical men. The author showed good judgment in leaving the revision of his valuable work to the Department of Engineering, now under the able direction of Captain W. D. Beach, 3rd Cavalry.

The Army at large is indebted to Lieutenant Root for presenting so satisfactory an exposition of one of the subjects for promotion of officers, especially since it has been adopted officially for this purpose, and the National Guard have already made good use of it and evince their appreciation of its practical value.

J. P. W.

Les Nouveantés Chimiques. Camille Poulenc. Paris: J. B. Baillière et Fils. 1896. Pp. 136, with 62 figures in the text.

The rapid progress of science today makes a work of this kind, giving a description of new laboratory apparatus and new methods of research applied to science and industry, extremely useful, especially when there is added an expert's opinion as to the value of each invention.

Doctor Poulenc's work divides the subject-matter into five sections, the first comprising apparatus of a general character, the second purifying apparatus, the third analytical apparatus, the fourth electrical apparatus, and the last biological and bacteriological apparatus. The discription of the pieces of apparatus are clear and simple, and generally illustrated by good figures in the text; the method of using the apparatus is fully explained; and the advantages and value of each are definitely stated.

The pieces of apparatus of special interest to those in charge of government laboratories (chemical, medical or physical) are:

The *universal gas volumeter* of Dr. Lunge, which finds application in the analysis of guncotton and dynamite and their derivatives, as well as in the determination of carbon in iron and steel; the new *ureometer* of M. G. Mercier, which is easy to handle and accurate in its results; the new *boron-corbon cell* of M. Warren, which gives a current of 2.5 volts at a cost of 2 cents an hour; the *air steriliser* of Dr. Morax, so constructed that when the burner is removed after the thermometer reaches 170° c. the interior retains a temperature of at least 160° for 15 minutes; the *aseptic filter* of M. Schlumberger, which has been tested by several prominent chemists and found to perfectly sterilize river waters; the platinum or porcelain *crucible* of Gooch, used to filter solutions (without the use of filter paper) and determine without loss such precipitates as barium sulphate etc. (in the analysis of gunpowder etc.); the *multiple funnel holder* of Baums et Cie, for liquids which filter slowly, the filtrates from the several funnel flowing into a single tube and then into the receptacle.

The value of this little publication (which is to be issued as an annual if found useful) is evident, and deserves the encouragement it seeks.

J. P. W.

Die Kriegswaffen, von Emil Capitaine und Ph. von Hertling. Vol. VII, No. 4. Rathenow: Max Babenzien. M. 1.50.

This number of the magazine of the latest constructions of arms is worthy of special mention.

It contains the Seabury (Bergen Point, N. J.) breech mechanism; improvements in the closing of the cylinder of small arms by the Mauser Factory; a sight for small arms with two openings and a cross-shaped front sight by von Hefner-Alteneck; a frame work for holding small arms and utilizing the recoil to open the breech-block; the McClean (Washington) rifle with drum magazine and an artillery projectile which is made a canister, shell or shrapnel by changing the bursting charge.

J. P. W.

BOOK NOTICES.

[These books will be fully *reviewed* as space becomes available.]

National Defenses, by Major-General Maurice, C. B. New York: The Macmillan Company, 66 Fifth Avenue. Pp. 209. $1.00.

Ulysses S. Grant and the Period of National Preservation and Reconstruction. By William Conant Church. New York. G. P. Putnam's Sons. Pp. 473. Cloth $1.50.

Naval Gunnery: a Description and History of the Fighting Equipment of a Man-of-war, by Captain H. Garbett, R. N. New York: The Macmillan Company. 66 Fifth Avenue. Pp. 360. $1.50.

The Campaign of Marengo, with comments, by Herbert H. Sargent, First Lieutenant, Second Cavalry. Chicago: A. C. McClurg and Company. Pp. 240. $1.50.

Bofors Naval quick-firing Guns. Stockholm, Sweden.

Bofors Mechanism for quick-firing Guns. Stockholm, Sweden.

Physical Drill for Foot Troops. Compiled by Captain Constantine Chase, Fourth Artillery. Washington, D. C.: James J. Chapman. Pp. 29, with plates; price twenty five cents.

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INDEX TO CURRENT ARTILLERY LITERATURE.

PERIODICALS CITED.

Abbreviations employed in index are added here in brackets.

All the periodicals are preserved in the Artillery School Library, Fort Monroe, Virginia.

ENGLAND.

Aldershot Military Society. *Occasional.*
Aldershot. Copies 6*d each.*

Arms and Explosives. [*Arms and Ex.*] *Monthly.*
Effingham House, Arundel Street, Strand, London, W. C. Per year 7 *s.*

Army and Navy Gazette. [*A. and N. Gaz.*] *Weekly.*
3 *York Street, Covent Garden, London. Per year* £1 12*s* 6*d.*

Canadian Military Gazette. [*Can. Gaz.*] *Fortnightly.*
Box 2179 *Montreal, Canada. Per year* $2.00.

The Engineer. [*Eng.*] *Weekly.*
33 *Norfolk Street, Strand, London. Per year* £2 6*d.*

Engineering. [*Eng'ing.*] *Weekly.*
35-36 *Bedford Street, Strand, London, W. C. Per year* £2 6*d.*

Journal of the Royal United Service Institution. [*Jour. R. U.S.I.*] *Monthly.*
17 *Great George Street, London, S. W. Per year* 24 *s.*

Journal of the United Service Institution of India. [*Jour. U. S. I. India*] *Monthly.*
Simla, India. Per year $2.50.

Photographic Journal. [*Photo. Jour.*] *Monthly.*
12 *Hanover Square, London.*

Proceedings of the Institution of Civil Engineers. [*Proceedings I. C. E.*]
25 *Great George Street, Westminister, London.*

Proceedings of the Institution of Mechanical Engineers.
[*Proceedings I. M. E.*] 19 *Victoria Street, Westminister, London.*

Proceedings of the Royal Artillery Institution. [*Proceedings R. A. I.*] *Monthly.*
Woolwich, England.

Professional Papers of the Corps of Royal Engineers.
[*Prof. Papers Corps Royal Eng'rs.*]
Chatham, England.

Review of Reviews. [*Rev. of Rev. Austral.*] *Monthly.*
169 *Queen Street, Melbourne, Australia. Per year* 11 s. 6 d.

Transactions of the Canadian Institute. [*Trans. Canadian Inst.*]
58 *Richmond Street, Toronto, Canada.*

Transactions of the Canadian Society of Civil Engineers.
[*Trans. Canadian Soc. C. E.*]
Montreal, Canada.

Transactions of the East of Scotland Tactical Society.
[*Trans. E. of S. Tactical Soc.*]
51 *Hanover Street, Edinburgh, Scotland.*

Transactions of the Institute of Naval Architects.
[*Trans. Inst. Naval Architects.*]
5 *Adelphi Terrace, London, W.C.*

United Service Gazette. [*U. S. Gaz.*] *Weekly.*
4-6 *Catherine Street, Strand, London, W. C. Per year £*1 10*s* 6*d.*

FRANCE.

L'Avenir Militaire. [*Avenir.*] *Semi-weekly.*
13 *Quai Voltaire, Paris. Per year* 18 *Fr.*

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Le Yacht—Journal de la Marine. [*Yacht.*] *Weekly.*
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GERMANY.

Allgemeine Militaer-Zeitung. [*A. M.-Zeitung.*] *Semi-weekly.*
Darmstadt. Per year 24 *M.*

Archiv fuer die Artillerie-und Ingenieur Offiziere. [*Archiv.*] *Monthly.*
Koch Strasse, 68-78, *Berlin, S. W.* 12. *Per year* 12 *M.*

Beiheft zum Militaer-Wochenblatt. [*Beiheft.*]
Koch Strasse, 68, *S. W.*, *Berlin.*

Deutsche Heeres-Zeitung. [*Heeres-Zeit.*] *Semi-weekly.*
Wilhelmstrasse 15, *Berlin. Per year* $6.00.

Internationale Revue. [*Int. Revue.*] *Monthly.*
Blasewitzer Strasse 15, *Dresden. Per quarter* 6 *M.*

Jahrbuecher fuer die deutsche Armee und Marine. [*Jahrbuecher.*] *Monthly.*
Mohren Strasse, 19, *Berlin, W.* 8. *Per year* 32 *M.*

Kriegswaffen. [*Kriegswaffen.*] *Monthly.*
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Marine Rundschau. [*Mar. Rundschau.*] *Monthly.*
Koch Strasse, 68-70, *Berlin. Per year* 3 *M.*

Militaer-Wochenblatt. [*Wochenblatt.*] *Fortnightly.*
Koch Strasse, 68, *Berlin, S. W.* 12. *Per Year* 20 *M.*

Militärische Rundschau. [*Mil. Rundschau.*] *Monthly.*
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Stahl und Eisen. [*Stahl u. Eisen.*] *Fortnightly.*
Schadenplatz 14, *Düsseldorf. Per year* $5.00.

Umschau, Die. [*Umschau.*] *Weekly.*
Frankfort a. M. Per year 10 *M.*

AUSTRIA.

Mittheilungen ueber Gegenstaende des Artillerie und Genie-Wesens.
[*Mitth. Art. u. G.*] *Monthly.*
Wien, VI, Getreidemarkt 9. *Per year* 1 *Fl.* 50 *Kr.*

Mittheilungen aus dem Gebiete des Seewesens. [*Seewesens.*] *Monthly.*
Pola. Per year 14 *M.*

Organ der Militaer Wissenchaftlichen Vereine. [*Vereine.*]
Wien I, Stauchgasse No. 4. *Per year*, 8-14 *numbers*, 6 *Fl.*

Zeitschrift des Oesterreichischen Ingenieur und Architekten Vereines.
[*Z. Architekten Vereines.*] *Weekly.*
I. Eschenbachgasse, No. 9, *Wien. Per year* 10 *Fl.*

SWITZERLAND AND BELGIUM.

Allgemeine Schweizerische Militaer-Zeitung. [*A.S.M. Zeitung.*] *Weekly.*
Basel, Switzerland. Per year, 8 *Fr.*

La Belgique Militaire. [*Belgique M.*] *Weekly.*
Rue St. Georges 32, *Ixelles, Belgium. Per year* 12.50 *Fr.*

Monatschrift fuer Offiziere Aller Waffen. [*Monatschr.*] *Monthly.*
Frauenfeld, Switzerland. Per year 5 *Fr., plus postage.*

Revue de l'Armée Belge. [*A. Belge.*] *Bi-monthly.*
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Revue Militaire Suisse. [*R. M. Suisse.*] *Monthly.*
Escalier-du-Marché, Lausanne, Switzerland. Per year 10 *Fr.*

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Monthly.
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La Prensa Militar. [*Prensa.*] *Weekly.*
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Revista da Commissao Technica Militar Consultiva. [*R. da Commiss*
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Revista Militar. [*R. Mil. Chile.*] *Monthly.*
Santiago, Chili.

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Artillerie-Tidskrift. [*Art. Tids.*] *Bi-monthly.*
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Militaert Tidsskrift. [*M. Tids.*] *Bi-monthly.*
Copenhagen, Denmark. Per year, U. S., $2.50.

Norsk Militeert Tidsskrift. [*N. M. Tids.*] *Monthly.*
Christiania, Norway. Per year, U. S., $2.50.

RUSSIA.

Artilleriiskii Journal. [*Art. Journal.*] *Monthly.*
Furschtatskaia Ulitza, St. Petersburg, Russia.

Razviedchik. [*Razv.*]
KoloKolwaia Ulitza, No. 14, *St. Petersburg, Russia.*

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Wadizdinskia Ulitza, No. 48, *St. Petersburg, Russia.*

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i Artiglieria é Genio. [*R. Artig.*] *Monthly.*
Tipografia Voghera Enrico, Rome. Per year 30 *L.*

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Engineer and Railroad Journal. [*Eng. and Rail. Jour.*]
nthly.
47 *Cedar Street, New York City. Per year* $3.00.

Journal of Mathematics. [*Jour. Math.*]
John Hopkins University, Baltimore, Md.

Machinist. [*Amer. Mach.*] *Weekly.*
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Manufacturer and Iron World. [*Man. and Iron World.*] *Weekly.*
59 *Ninth Street, Pittsburgh, Pa. Per year* $4.00.

f the Office of Naval Intelligence. [*Naval Intelligence.*]
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New York City. Per year $6.00.

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of the American Mathematical Society. [*Bulletin Math. Soc.*]
University Heights, New York City.

Magazine. [*Cas. Mag.*] *Monthly.*
World Building, New York City. Per year **$3.00.**

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Engineer. [*Elec. Eng.*] *Weekly.*
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Electricity. [*Jour. Elec.*] *Monthly.*
421 *Market Street, San Francisco, Cal.*

Schweizerische Zeitschrift fuer Artillerie und Genie. [*S. Zeitschrift.*]
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Journal American Society of Naval Engineers. [*A.S.N. Egrs.*] ***Quarterly.***
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Journal of the Association of Engineering Societies. [*Eng. Soc.*] *Monthly*
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Journal of the Military Service Institution. [*Jour. M. S. I.,*] ***Bi-monthly.***
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Journal of the U.S. Cavalry Association. [*Jour. U. S. Cavalry*] ***Quarterly.***
Fort Leavenworth, Kansas.

Journal of the Western Society of Engineers. [*W. Soc. Eng.*] ***Bi-monthly.***
1737 *Monadnock Block, Chicago, Illinois. Per year* $2.00.

Marine Review. [*Mar. Rev.*] *Weekly.*
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Military Information Division. [*Mil. Information Div.*] *Occasional.*
War Department, Washington, D. C.

Notes on Naval Progress. [*Naval Intelligence.*] *Occasional.*
Navy Department, Washington, D. C.

Pennsylvania Magazine of History and Biography. [*Penn. Mag. of Hist.*]
Quarterly.
13 *Locust Street, Philadelphia. Per year* $3.00.

The Photographic Times. [*Phot. Times.*] *Weekly.*
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Physical Review. [*Phys. Rev.*] *Bi-monthly.*
Cornell University, Ithaca, New York. Per year $3.00.

Popular Science Monthly. [*Pop. Sc. Mo.*] *Monthly.*
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Proceedings of the American Philosophical Society.
[*Proceedings of A. Phil. Soc.*]
104 *South Fifth Street, Philadelphia, Pa.*

Proceedings of the U. S. Naval Institute. [*Naval Inst.*] ***Quarterly.***
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Public Opinion. [*Pub. Opin.*] *Weekly.*
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Review of Reviews. *Monthly.*
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The Scientific American. [*Scien. Amer.*] *Weekly.*
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Technology Quarterly. [*Tech. Quart.*] *Quarterly.*
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Transactions American Institute of Electrical Engineers.
[*Inst. Elec. Eng'rs.*] *Monthly.*
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[*Trans. Inst. Min. Eng'rs.*]
P. O. Box 225, *New York City.*

Transactions of the American Society of Civil Engineers.
[*Proceedings A.S. Civil Eng'rs*]
127 *East* 23*d Street, New York City.*

Transactions of the American Society of Mechanical Engineers.
[*Trans. A. S. Mech. Eng'rs.*]
12 *West* 31*st Street, New York City.*

Transactions of the Society of Naval Architects and Marine Engineers.
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12 *West* 31*st Street, New York City.*

Western Electrician. [*West. Elec.*] *Weekly.*
510 *Marquette Building, Chicago, Illinois. Per year* $3.00.

Wilson's Photographic Magazine. [*Phot. Mag.*] *Monthly.*
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ORGANIZATION AND ADMINISTRATION.

Rapid fire field guns.—**R. M. Suisse**, July 15.
Some ideas on naval reform.—**Marine F.**, July.
Foreign navies.—**R. Maritime**, June.
Preparedness for naval war.—**R. Maritime**, July.
Coast defense.—**R. de Marina**, May.
The British army and navy.—**Int. Revue**, July, August.
The cavalry reorgnization.—**A. and N. Gaz.**, May 1.
The condition of our army.—**A. and N. Gaz.**, July 10.
The English admirality.—**Yacht**, August 7.
English sea-coast artillery.—**R. Artillerie**, July.
The naval power of England.—**Yacht**, July 31.
The Canadian militia.—**A. and N. Jour.**, August 7.
The German army in 1897.—**Cercle**, July 10.
Urgent reforms for the infantry.—**Cercle**, July 3, 10, 17, 24, 31.
Colonization and the Colonial army.—**Avenir**, July 23.
Reorganization of the general staff.—**Avenir**, July 16, 20.
The present organization of the engineer troops of the Russian army.—**Etranger**, June, July.
The Russian fortification troops.—**Jahrbuecher**, August.
The development of the Russian war power.—**A. S. M. Zeitung**. August 14.
The army of Spain.—**A. and N. Jour.**, August 14.
The war powers of the United States and Spain compared.—**Int. Revue**, August.
Organization of the companies of telegraphers.—**Engenheria Mil.**, July.
The reorganization of the Italian army.—**Int. Revue**, August; **Wochenblatt**, July 3, August 11; **Cercle**, July 3; **Etranger**, July; **Avenir**, July 23.
The Italian cavalry.—**R. Cav.**, June; **Belgique M.**, August 1.
Reorganization of the Garde-Civique.—**Belgique M.**, June 20, July 18, 25.
Organization of the army.—**Belgique M.**, June 20.

Militia of the Lakes.—**Mar. Rev.**, August 12.

The militia of the United States.—**Wochenblatt**, August 14.

The navy of the United States.—**Yacht**, July 10.

The army strength of Turkey.—**N. M. Tids.** No. 4.

Short notes on the Montenegrin army.—**Proceedings R. A. I.**, June.

Military organization of Montenegro.—**Etranger**, July.

The Roumanian army.—**Int. Revue**, July.

Supply department and military railway system formerly and now.—**N. M. Tids.** No. 4.

Infantry accoutrements, model 1896.—**R. M. Suisse**, July 15.

The national guard.—**Porvenir**, June 16, 24.

Observations upon the organization of military colonies.—**Exercito**, July.

The Argentine navy.—**Prensa**, June 30.

TACTICS, STRATEGY, AND MILITARY HISTORY.

The strategical importance of the Carpathians.—**Int. Revue**, July.

Napoleon's political status and preparations for the war of 1805.—**Int. Revue**, July, August.

The Greco-Turkish war.—**Int. Revue**, July.

Mobility of light artillery.—**Art. Tids.**, Nos. 2 and 3.

Horse artillery with cavalry.—**Art. Tids.**, Nos. 2 and 3.

A few remarks about the field exercises of light artillery.—**Art. Tids.**, Nos. 2 and 3.

Tactical practice marches for light batteries.—**Art. Tids.**, Nos. 2 and 3.

Groups of batteries.—**M. de Art.**, June.

Battleship seamanship.—**A. and N. Jour.**, August 8.

Two operations in woods, 1866 and 1870.—**Jour. R. U. S. I.**, July.

Naval tactics and strategy.—**Razv.**, No. 345, 352.

Napoleon and Wellington.—**Wajennij Ssbornik**, VI.

Direct and indirect fire.—**Proceedings R. A. I.**, May.

Naval tactics.—**R. de Marina**, July 31.

The choice, occupation and change of positions by field artillery.—**Proceedings R. A. I.**, July.

The Greco-Turkish war of 1897.—**Etranger**, June; **A. M. Zeitung**, June 28.

Cavalry fighting on foot.—**R. Cav.**, June.

Remarks on the Greco-Turkish war.—**R. Inf.**, July.

Masked field artillery positions.—**Vereine**, No. 2.

Security and information in mountainous country.—**Vereine**, No. 2.

The fire tactics of Infantry since 1793.—**Monatschr.**, July.

Coast defense.—**A. and N. Gaz.**, August 7.

The tactics of infantry and battle tactics, 1896.—**Wochenblatt**, July 3.

On posting the artillery in two lines.—**Wochenblatt**, July 31; August 4.

The Turkish army (von der Goltz).—**Wochenblatt**, July 24, 31; August 4, 7.

Armies and the conduct of war.—**Wochenblatt**, August 14.

Field artillery in future wars and its proper instruction.—**Archiv.**, May-June.

On the reliability of determining the range, (Rohne).—**Archiv.**, May-June.

Conduct of the fire of a field battery.—**R. Artig.**, May.

Developments in art of war.—**Umschau**, July.

Rear and flank guards.—**Heeres-Zeit.**, July 21.

A fleet for offense or defense.—**Heeres-Zeit.**, July 28.

Artillery questions discussed from a tactical standpoint.—**Heeres-Zeit.**, July 31; August 14.

The role of cavalry in the service of security and information.—**R. Cav.**, June.

From Bautzen to Pläswitz, May, 1813.—**R. Cav.**, June.

Instructions in security and information, 1897 (Swiss).—**A. S. M. Zeitung**, July 24.

Combined naval and military expeditions (Vice-admiral Colomb).—**Prof. Papers R. E.**, 1896.

The question of machine guns with cavalry.—**Vereine**, No 1.

Tactical problem No. 8.—**Monde**, August 1.

The offensive.—**Monde**, July 15; August 1.

Armies past and present.—**R. Univ.**, August.

Maritime war.—**R. M. Brazil**, May-June.

Naval limit of combat against torpedo boats.—**R. de Marina**, May.

The next naval war.—**R. de Marina**, May.

The battle of Minden.—**U. S. Gaz.**, July.

Battle of Naseby.—**Jour. R. U. S. I.**, July.

The battle on the Trebbia, June 20, 1799.—**Razv.**, No. 346.

The battles around Metz in 1870, during the siege, and their tactical teachings.—**A. Belge**, May, June.

The retreat of McMahon's army after Wörth.—**Beiheft**, No. 5 and 6.

The affair on the Göhrde (1813).—**Beiheft**, No. 5 and 6.

The naval battle at Lissa.—**Seewesens**, VIII.

The last fight of the Sioux war.—**Jour. U. S. Cavalry**, June.

The battle of Domokos.—**Monatschr.**, July.

The operations against Vinoy, September, 1870.—**Wochenblatt**, July 20.

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Kitchen ranges for barracks (well illustrated).—**R. Artig.**, July-August.

CORRECTION.

(See table page 91, *Journal U.S. Artillery*, Volume VIII, No. 1.)

A Test of Krupp Armor.—In a recent reference made in *The Iron Age* test of a Krupp armor plate, the statement was printed that the plate tion was through cracked at the fifth shot. This was a mistake, since were only surface cracks, quite a common appearance on surface har plates. Besides, the penetration of round five was only 4.1 inches, and 7.7 inches as stated. It may be noted also that after the fifth round additional rounds with 8-inch and 6-inch armor piercing shells were fir the tapered part of the plate without cracking it. The point is made that effect of round five does not give a correct idea of the power of res the plate, since the points of impact of rounds one and five were too together, their centers being only 16 inches apart. This part of the therefore, had certainly lost the better part of its power of resistance being struck by round five. The other points of impact were very together, being about two feet apart from each other and from the e the plate.—*The Iron Age*, July 1, 1897.

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THE WELDON RANGE FINDER, ITS USE AND ITS THEORY.

In the field some such device as this is of great assistance to light artillery. To be of great service in the field a range finder must have to a reasonable degree the following qualifications:

1. Portability; 2. Durability; 3. Accuracy; 4. Adaptability to accidents of the ground; 5. Simplicity of manipulation; 6. Stability; 7. As far as possible the instrument should combine the best characteristics of all classes of range finders, with as few as possible of the objectionable ones, the purpose of the range finder being kept in view.

The Weldon is essentially a field range finder. It is meant for rapid and usefully accurate range firing.

It possesses the first two (portability and durability) of the above requisites to a satisfactory degree, weighing only four ounces and may be carried in the vest pocket; and also being strongly constructed of metal with crown glass prisms, and having a metal cover and on the outside of this a thick leather case.

As to accuracy, the requisite degree of this must be determined by the method of fire. If the firing is to be done assuming that the range finder is absolutely correct in its results, then it is necessary that a more accurate range finder than this or any other field range finder known to the writer be used; but if a means is desired of promptly finding the range with close approximation for a first shot in "bracketing" the target, this range finder will be useful.

In regard to the use of range finders, Colonel John I. Rodgers, 5th Artillery, says:

"The range finder is of assistance in eliminating the great errors which may arise in estimating distances. With a reliable instrument and skilful takers the distance measured should taken to govern the elevation for the first shot."

It is to be noticed that this indicates that the range finder is be used no further for that target. If used further the ran finder is a fruitful source of error, as the deterioration of powde state of the air with reference to moisture and other conditior modify the accuracy of the range-table under the circum stances.

Elsewhere, Colonel Rodgers states, "Range finders should nc be made use of when the range is easy or the target of a trans tory nature, such as advancing infantry."

From the above it will be seen that a range ascertained withi 3% of the correct distance is of material assistance; and it is fai to presume that a reasonable time will be allowed the range part in which to make the observation.

The error of this instrument under average conditions is les than 3% of the correct value.

As two points, one seen directily and the other by reflectio and refraction, may be made to coincide in this instrument b making the axis of the prism perpendicular to the plane of th eye, the point whose distance is required, and the direction poin it is easily seen that no instrument could well be more adaptabl to varieties of ground than this.

Its simplicity of manipulation may be shown by the statemen that, at present, every non-commissioned officer and severa privates (these enumerated being the only ones instructed in it use), in this battery (E, 1st Artillery) is capable of making a estimate of distance with it, within 3% of the truth.

Its stability is self-evident. The angles of the prisms are fixe and can be changed only by re-grinding. Should they becom detached from fastenings (highly improbable) each prism ma still be used for its original purpose.

It is not adjustable and is the more accurate on that account This range-finder belongs to that class of telemeters having fixed parallax and a base proportional to the measured distance It may also be said to have to a certain degree the advantage of those telemeters which have a variable parallax, since the com binations of prisms give different parallaxes corresponding, eac to a different proportional base, ($\frac{1}{25}$, $\frac{1}{50}$, $\frac{1}{200}$).

The instrument referred to is the range finder of semi-cylin drical shape when closed and having three prisms of glass (ar ranged one above the other) having the following measurin angles:

1st or uppermost . . . . . 90°.
2d or middle . . . . 88° 51′ 15″ = $\tan^{-1}$ 50.
3d or lowest . . . . 74° 53′ 15″ = $\tan^{-1}$ 4.

The first is used in order to establish the direction of the base for an assumed starting point. The second used in connection with the first establishes an angle at the other end of the proportional base, the tangent of which is 50, the ratio of the range to the base. The third, whose use will be shown later, facilitates measurement and shortening the base, the ground being uneven. The principles on which this instrument depends are shown as follows:

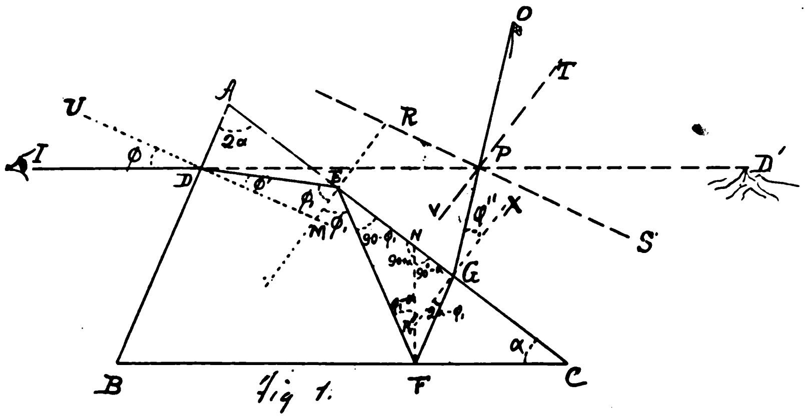


Fig. 1.

It is desired to show that in any right prism with a triangular base, *ABC*, the prism being composed of any substance forming a transparent isotropic medium, if used in the manner prescribed for the Weldon Range Finder prisms (to be shown later) the angle between the incident and emergent rays will be constant for that prism and equal to the face angle of the prism, provided that the face angle, (*A*), is twice as large as one (*C*) of the other angles; that the side (*BC*) opposite the face angle is silvered and that the angle made by the refracted ray *DE* with the normal to that face (*AC*) of the prism included between the angles *A* and *C* (already referred to) is greater than the critical angle for that medium.

Fig. 1 represents any cross-section (of the right prism of Fig. 2), that is parallel to the plane *C′A′B′*, the ray lying entirely within that plane of cross-section. In Fig. 2 such plane is roughly represented by the same letters used in Fig. 1.

In Fig. 1, *IDEFGO* represents the course of the refracted ray; *ID* represents the *direction* of the direct ray from the eye to the

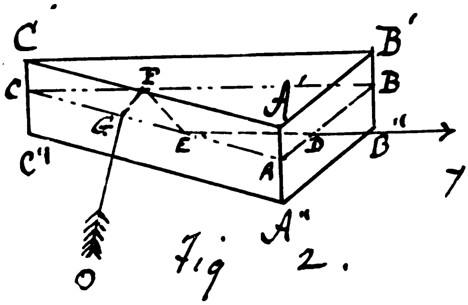


Fig. 2.

direction point. It is *not* the direct ray of actual use, which passes under the prism (through the "*window*") but it is parallel to said direct ray.

At D, E, F, and G, normals are drawn to the sides of this prism, dotted lines being used. Let μ be the relative index of the medium of the prism, with reference to that of the surrounding medium (air, say).

Though so drawn in the figures, ID is *not necessarily* parallel to BC, as will appear from the general nature of the discussion.

No restriction is placed upon the direction of ID save that it shall lie in the plane ABC and shall have such direction that the refracted ray shall strike AC and AB consecutively within the limits of the prism, and make with the normal to AC at the point of incidence (E, say) an angle less than the critical angle, that angle being (in this instance) $\sin^{-1}\frac{1}{\mu}$.

$$\left(\text{For crown glass, } \sin^{-1}\frac{1}{\mu} = 40^\circ\, 30'\right).$$

Let the value of A, the face angle, be represented by 2α, and that of C by $\alpha = \frac{1}{2}A$.

It is evident that $\alpha \leq 60^\circ$ theoretically; and, practically, it has a maximum value of 45°.

It is desired to show that $A = OPD'$, under the conditions of the proposition. O and I are points of the ray exterior to the prism and on different sides of it.

Before going further it is well to note that V being the velocity of transmission of light in the outer medium and V' being that of the material of the prism,

$$\mu = \frac{V}{V'} \text{ and of course}$$

$$\frac{1}{\mu} = \frac{V'}{V}.$$

Now, from optics we know that (φ being the angle made by ID with the normal to AB, and φ', $\varphi_{\prime}$, and φ'' being as indicated in Fig. 1) the following is true:

$$\sin\varphi = \mu \sin\varphi' \text{ and}$$

$$\sin \varphi'' = \frac{1}{\mu} \sin R'GF; \text{ and}$$

this is true in whichever of the two directions the ray is transmitted. Hence it is immaterial in the discussion whether the ray proceeds from I to O or from O to I. We will trace it from I to O.

It is thus evident that if the proposition as stated be proven, the eye of the observer may be either at I or O; in other words, both unsilvered faces of the prism, may (within certain limits) be used for the purpose of observing.

Let $IDU = \varphi$,
$EDM = \varphi'$,
$DEM = (MEF =)\ \varphi_1$ (angle of incidence = angle of reflection) and $PGX = \varphi''$.

Then,

$$\sin \varphi = \mu \sin \varphi' \quad \text{(Optics).}$$

$$\varphi' + \varphi_1 = 2a \quad \text{(Geometry).}$$

$\angle EFN$ (angle of EF with normal to BC) $= \varphi_1 - a$, (from triangle EFN) $= NFG$ (Reflection).

$$NGF = 180^\circ - (90^\circ - a) - (\varphi_1 - a) = 90^\circ + 2a - \varphi_1.$$

$$NFG - 90^\circ = R'GF = 2a - \varphi_1.$$

But

$$2a - \varphi_1 = \varphi'.$$

Hence

$$R'GF = \varphi'.$$

Now

$$\sin \varphi' \text{ (or } \sin R'GF) = \frac{1}{\mu} \sin \varphi''.$$

Hence

$$\sin \varphi'' = \mu \sin \varphi' = \sin \varphi.$$

Since a ray passing from one medium to another will always cross the normal to the dividing plane between the media, the emergent ray will take some such direction as GO. From the nature of the case, $\varphi'' < 90^\circ$. Hence, $\sin \varphi''$ being equal to $\sin \varphi$,

$$\varphi'' = \varphi.$$

Therefore the angle of incidence equals the angle of emergence.

This relation is true whatever the numerical value of μ. Hence the density of the medium makes no difference.

Furthermore $\varphi = \varphi''$ for all colors, though each color has its own index for a given medium.

Through P draw TV and RS, perpendicular to AC and AB respectively,

$$\varphi = \varphi'' = VPG, \text{ and } \varphi = RPD \quad \text{(Geometry).}$$

$$RPT = DME = 180^\circ - 2a.$$

$$\therefore \quad RPV = 2a = DPG.$$

Therefore the face angle A = the measuring angle, OPD'. From this it is evident that μ the index of the medium (representing its density) has no effect on the value of the measuring angle of a given prism.

A prism filled with water would give similar general results.

Now assume that the prism is made of optical glass; then $\mu = 1.54$, very nearly.

We know, $\varphi_1 + \varphi' = 2a$,

$$\therefore \quad \sin\varphi\ \mu \sin\varphi' = \mu \sin(2a - \varphi_1).$$

Now let us give, in turn, to $2a$, the value of the several face angles of the prisms of the Weldon Range Finder. They are

1st Prism	90°
2d Prism	88° 51′ 15″
3d Prism	74° 53′ 15″

Then let us find in each case what values φ may have, to give allowable values of φ_1, that is, values of φ_1 greater than the critical angle (40° 30′).

In the 90° prism, assume $\varphi_1 = 40^\circ\ 30'$.

Then

$$\sin\varphi = \mu \sin(2a - \varphi_1) = 1.54 \sin(90^\circ - \varphi_1) = 1.54 \cos 40^\circ\ 30',$$

from which we obtain

$$\log \sin\varphi = 0.06856,$$

whence $\sin\varphi > 1$, which is impossible. Therefore *no* ray can enter either AC or AB, and make an angle with the normal to AC, less than or equal to 40° 30′, and the ray at the same time fulfil the other conditions of the proposition.

Now let us suppose the extreme inclination to the normal and make $\varphi = 90^\circ$.

$$\sin\varphi = 1 = 1.54 \cos\varphi_1$$

whence

$$\varphi_1 = 49^\circ\ 30'.$$

Suppose now that $\varphi = 0$, or that the incident ray is normal.

Then,

$$\sin\varphi = \mu \sin\varphi',$$

or,

$$\varphi' = 0,$$

or the ray does not strike the face AC.

Hence the right angle *UDB* limits the useful rays and the position of the eye. Similarly, for the face *AC*, *XGA* is the limiting angle.

Hence we have the rule given in the book of instructions for the Weldon Range Finder, slightly modified.

There are two ways to hold the prisms:

1st. With the apex of the prism towards the eye. The reflection of an object to the right of the observer is to be sought in that corner of the prism which is farthest from the object.

2nd. It can be held with apex towards object, the object being to the observer's left; seek reflection in corner nearest object.

Next consider the second prism.

Assuming the critical value for φ_1, we find

$$\sin\varphi = 1.54 \sin(2a - \varphi_1) = 1.54 \sin 48^\circ\ 21',$$

which is greater than unity and φ has no possible value that will give the critical value to φ_1.

$$\text{If } \varphi = 90^\circ$$

$$\sin\varphi = 1 = 1.54 \sin(88^\circ\ 51'\ 15'' - {}_1)$$

Hence

$$\varphi_1 = 48^\circ\ 32'.$$

Give φ the value of 0°.

Then

$$\sin\varphi = 0 = 1.54 \sin(88^\circ\ 51'\ 15'' - \varphi_1).$$

Hence

$$\varphi_1 = 88^\circ\ 51'\ 15'',$$

or the ray after entering will ultimately pierce the face *AC*, but in most cases, beyond the termination *C* of the face *AC*; hence, practically, 0° and 90° will limit, (as in the case of the first prism) the direction of the eye and the object. Hence the same rules will obtain as in the first case.

Let us consider the third prism.

$$2a = 74^\circ\ 53'\ 15''.$$

$$\sin\varphi = \mu \sin(2a - \varphi_1) = 1.54 \sin(74^\circ\ 53'\ 15'' - 40^\circ\ 30').$$

$$\sin\varphi = 1.54 \sin(34^\circ\ 23'\ 15'').$$

Hence

$$\varphi = 60^\circ\ 26'.$$

Now supposing φ_1 to have its limiting value of 90°.

Then

$$\sin\varphi = 1.54 \sin(74^\circ\ 53'\ 15'' - 90^\circ) = -1.54 \sin(15^\circ\ 6'\ 45''),$$

giving

$$\varphi = -23^\circ\ 40',$$

or, in the case of the third prism the limiting angle of the ray differs somewhat from that of the other two prisms. It extends from the normal about 60° in the same direction as in the others; but has also about 20° of useful direction on the opposite side of the normal.

In practice, due to construction and imperfections, the limiting lines approximate more closely in direction to the normal, and the useful angle is therefore smaller.

In actual practice, however, the amount of rotation about its vertical axis that will be endured by any one of the three prisms, the prism meanwhile giving a steady coincidence of the real and apparent objects, is astonishing, unless the facts just shown be kept in view.

This should, I think, do away with the idea, which seems instinctive in so many cases, that great precision of pose of the observer is essential. In certain respects it is so, to a reasonable degree; but the idea that the line between the eye and the direction point should be either parallel with, or perpendicular to the plane of the mirror is erroneous.

As to the use of this instrument and the problems that may be solved with it, they are simple, and yet, in instructing enlisted men certain precautions must be observed.

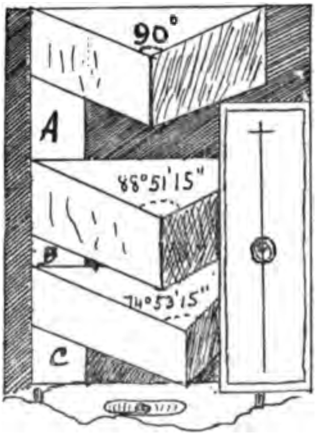


Figure 3

Fig. 3 is a very rough drawing, simply for showing the prisms. *A*, *B*, and *C* are the "windows" for direct view.

Ranges can be found with a single range finder; also by using two men and two range finders; and (quickest and most accurate of all) three men with a range finder each.

As regards preliminary practice, the men should not only learn to hold the instrument properly and to know a coincidence of images when they see one; but they should also be made to *pace yards*. The eight men under instruction in this battery, after about fifteen lessons can pace as follows:

One paces 100 yards in 100 steps almost every time.

Several pace about 99 yards.

The rest all pace within three yards of the hundred.

For the purpose of teaching them to do this they were made to pace between three stakes placed 117⅓ yards apart for the purpose of pacing the horses of the battery. Stakes 100 yards apart would have been better, the first twenty yards being marked off, as recommended in the Weldon range finder pamphlet.

The problems can all be found in that pamphlet. They will be outlined to some extent here, and methods of procedure explained briefly.

The simplest, and usual, problem is this:

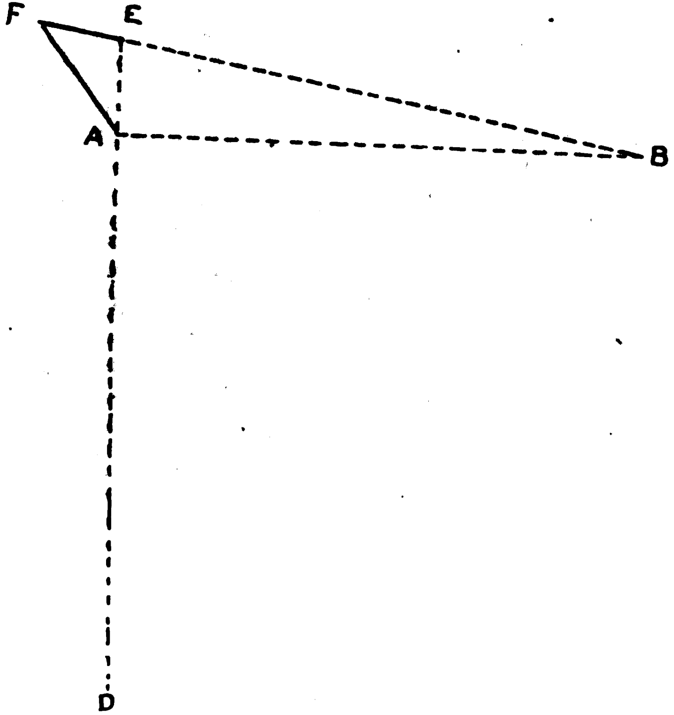


Fig. 4

To find the range of a distant point using the first and second prisms.

Let *B* be the distant object whose range is sought. *B* is known as the "range point." Then plant a stake at *D*, which is then called the direction point, so that seen from *A* with the naked eye it coincides with the image of some definite point of *B* seen in the prism. Then plant a stake at *A*. Move backwards on this line towards E, observing D directly and B with second prism. As long as the image of B remains on the same side (left in this case) of D, continue to retreat; when it coincides, halt and mark the spot; if it appears on the other side (right in this case), advance towards A, and halt on coincidence. Measure EA. $AB = 50 \times EA$.

In this connection, the third prism may be used.

In the practical use of this instrument it may be interesting to note the especial value of the third prism.

Suppose $AB = 5000$ yards.
Then $EA = 100$ yards.

Suppose EA to be covered with undergrowth, mud, marsh, or something similar, or to be very uneven ground cut up by gullies, etc. It is also too long a distance over which to stretch a tape. Then the third prism is useful as follows:

Plant a stake at E; move backwards in prolongation of BE using *third* prism and observing stake at A. When the image of A coincides with E and B seen directly halt and notice exactly where the instrument was. Take the point vertically below it and measure accurately the distance EF with a tape line.

$$EF = \tfrac{1}{4}\, EA = \tfrac{1}{200} \text{ Range.}$$

It is apparently strange, but distances estimated by the use of the third prism are more accurately measured than by the use of the first and second even on good ground. For, as will be shown, the use of the third prism tends to compensate for any error in the location of E and gives in such a case, a more correct result than the measurement of EA.

Besides this, in moving backward on EA using the second prism, the object B is generally so distant that the coincidence of direct and reflected images is very gradually obtained, as many as three or four steps may sometimes be taken backwards amounting to 1½ or 2 yards before any apparent change is noticed, especially if the eye is tired by continued work. But in using the third prism, retiring along EF, the stake at A, being only a short distance away, allows its image to move with comparative rapidity, so that a difference may be noticed by moving the body forward or backward, the feet remaining in place. Then, too, $\frac{1}{200}$ of 5000 yards (probably as long a range as would be likely to occur) is only 75 feet, which could be measured with a stretched tape line, to inches if necessary.

Now, to show that the use of the third prism tends to compensate for error in the length of AE.

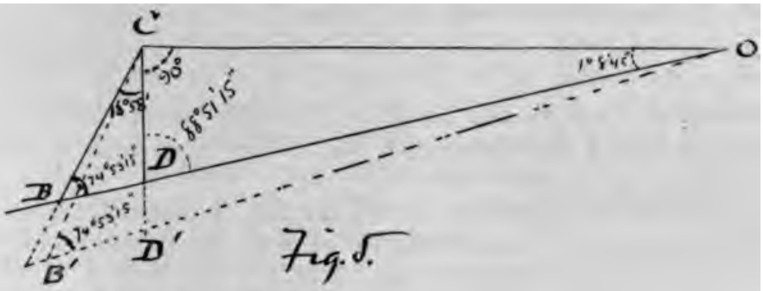


Fig. 5.

In the triangle *CBD*,

$$\frac{CD}{BD} = \frac{4}{1} = \frac{\sin.\ 74^\circ\ 53'\ 15''}{\sin\ 13^\circ\ 58'}$$

Now suppose *CD* to vary in length, the angle *CBD* remaining constant and equal to 74° 53′ 15″, then *BD* and the angle *BCD* would also change. As *CD* increases (suppose) becoming *CD′*, then, *B* moving to *B′* and angle *B* remaining constant in its new position, the angle *BCD* must decrease for *COD* increases and the other angle *B* of the triangle *BCD* remains constant. Let the changing values of *BCD* be represented by z, those of *CD* by x and those of *DB* by y.

Then for any position, *B′CD′* for instance, z decreases as x increases, as shown above.

It remains to find, within the desired limits, what effect a change in x has on y.

$$\frac{y}{\sin z} = \frac{x}{\sin 74^\circ\ 53'\ 15''} = \frac{\sin\ (13^\circ\ 58' \pm \text{"change" in } z)}{\sin 74^\circ\ 53'\ 15''}$$

Now when the "change" from 13° 58′ is zero, we have,

$$\frac{y}{x} = \frac{1}{4}.$$

When "change" is positive,

$$\frac{y}{x} > \frac{1}{4}.$$

When "change" is negative,

$$\frac{y}{x} < \frac{1}{4}.$$

But x decreases as z increases and *vice versa;* hence, when x increases from its proper value *CD*,

$$\frac{y}{x} > \frac{1}{4};$$

and when x decreases from that value

$$\frac{y}{x} < \frac{1}{4}.$$

Hence *BD* suffers from an error in the determination of *CD*, but does so to a less degree than does *CD* itself. Hence, it tends to compensate for such error.

This may be tested and proven by any numerical example, presuming an error in x, finding range from that erroneous value, and then finding $B'D'$ by solving $CB'D'$.

If true range is 2500 yards; x, as determined is 48 yards, say.

Then range is found to be 2400, by using x as base.

Now use y as base, solve triangle and find, $y = 12.04$, giving range = 2408, more nearly correct.

ALSTON HAMILTON,
Second Lieutenant, First Artillery.

APPENDIX.

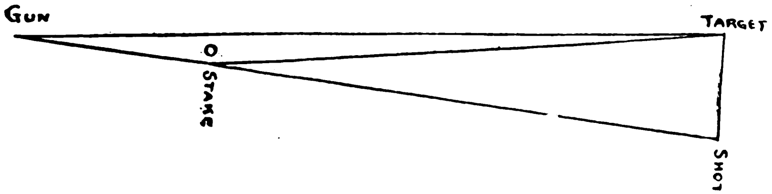
A very proper and useful purpose to which the Weldon Range Finder may be put, apart from those for which it was designed, is the laying of field guns in direction for indirect fire. It is well known that indirect fire has never been officially recognized nor considered in the field practice of our light artillery and therefore no means have been provided for laying guns by that very important, and in this modern day, that very necessary method.

For elevations, any accurate quadrant can be used, a seat on the guns being properly prepared. To give direction, there appears to be no method at hand, except by plummets as in mortar laying, or stakes placed in front or rear of the concealed battery on the principle of the plummets. Plummets are cumbersome and only available under most favorable conditions, while stakes necessitate the exposure to the enemy of a number of men, thus advertising the presence of the battery—the very thing we are anxious to avoid.

By the use of the Weldon range finder we escape the disadvantages above enumerated and gain the very important advantage of speed. In indirect laying, the problem to be solved is the establishment of a point on the line joining the battery (center or flank) with the target, which shall at the same time be visible from the guns. The battery having been placed on ground invisible from the target, two men, one with the range finder and another with a stake some five feet long advance towards the target, keeping concealed, and seek some position 200 yards in front of the guns from which both guns and target may be seen, but in such position as to show only a head to the side of the enemy. The man with the stake should be entirely concealed. By care in the selection of this ground and in their movements, no indication of the presence of the battery need be given the enemy by the range finder party. Using the upper or 90° prism, the stake is established about 100 yards away from the observer and on a line from the observer at right angles to the line joining the observer and the target. By reversing the prism, the observer then notes the position of the guns with reference to this latter line. If there is not a coincidence with the stake and the gun, then the observer is not on the line joining the battery and the target. By moving to the front or rear, right or left as the case requires, constantly reversing the prism so as to watch both coincidences, the observer soon finds a point where the line joining it and the stake makes right angles with the lines joining this point with the battery and target. He is therefore on the line joining the battery (a selected gun) with the target. This operation is very simple and can be done very rapidly after short practice.

Stakes may be planted for each gun of the battery, either by the above method or by laying off the intervals between stakes to correspond to those in the battery. It may be found necessary to plant a second stake in order to fix the line, which can be readily done, although it would seem better to fix two stakes at measured distances from the wheel and trail of each piece, thus permitting the gun to be run back to its first position after each fire.

In order to test the value of this method for laying guns in direction, two points were selected over two thousand yards apart. The point on which to lay was first found by means of the Weldon Range Finder and then a transit was carefully set up over this point and directed on the battery and target. The angle at the interpolated point was found to be 179° 56′ showing an error of only 4′.



In order to find what error in a lateral direction this error of 4′ would make in the firing, supposing the laying to have been accurately done, we solved the above triangles to find, first angle TGS at the gun, and then the distance TS or lateral de tion of the shot at the target due to this angle. The angl was found to be 1′ 12″ and the deviation due to this to be c yards. I may add, also, that the stake O was established v hurriedly, not over 30 seconds being used. By actual and ca ful measurement the distance $GO =$ 156.93 yards and the dista OT taken from a good map is 1883.33 yards. I might add passing, that this distance measured with the range finder 1867.25 or within less than one per-cent of the true distance, was made by non-commissioned officers of Light Battery E, Artillery.

The conclusion from my practice and this test convinces that the Weldon range finder can be used for rapid, safe accurate establishment of direction of fire in indirect laying, in almost any topographical conditions will be found of pract use.

First Lieutenant H. L. Hawthorne,
First Artillery.

EXPLOSIVES.

A study by Nikolaus Ritter von Wuich, Colonel, Commandant of the Technical Military Courses of Instruction.

Mittheilungen über Gegenstände des Artillerie-und Genie-Wesens, 1897, No. 7.

INTRODUCTION.

An important step in recent attempts to increase the efficiency of guns, is the use of charges for the projectiles composed of explosives possessing a potential energy considerably greater than that of the old powder, by which means the total energy of the projectile, made up of the energy of motion (kinetic energy) of the latter and the interior potential energy of the bursting charge, has been considerably increased.

Such projectiles are called, in general, high explosive projectiles; we will divide them, according to their use, into high explosive shell and high explosive shrapnel, understanding, of course, that the same projectile—furnished with double fuse—may be used either as shell or as shrapnel.

Whereas in modern gunpowder the great object is to produce *explosion* by gradual combustion, carefully avoiding the highest development of energy—the so-called detonation—; in bursting charges, on the other hand, every effort is made to insure the latter effect, and to effect this are applied the usual means: "complete filling of all the space, and energetic explosion by means of a detonating preparation."

In consequence of the *detonating* [illegible] *high explosive shell* are better adapted [illegible] than the old powder shell; indeed, they [illegible] act as a sort of open mine and [illegible] were possible to bring about detonation [illegible] but to accomplish this a great [illegible] of the fuse is necessary—a very [illegible]

In the case of high explosive shrapnel [illegible] common to ordinary shell we [illegible] of extraordinarily large angle [illegible] projectile moving in a sort of [illegible] gave rise to the idea of using the high explosive shrapnel as th principal projectile for attacking objects behind cover.

Indeed, the advocates of this system went further, and advanced the view that the vertical action of high explosive shrapnel would enable us to dispense altogether with the highly curved trajectory, which latter involves a special field piece (mortar or howitzer).

Our own opinion is that the greater the flatness of the trajectory of the principal field piece, the more is the necessity for the highly curved trajectory to be emphasized, since it is an important requisite for other purposes besides the attack of objects behind cover; in other words, that the highly curved trajectory would then more particularly and definitely have its *raison d'être* after we succeeded, by the application of a practicable and rapid process, in attacking objects behind cover effectively with high explosive shrapnel.

But even should we fail to discover such a mode of firing, it is nevertheless possible, under especially favorable circumstances, to obtain effective action with high explosive shrapnel against objects behind cover. Under such circumstances we must regard the principal purpose of the high explosive shrapnel as that of a shell, *i. e.*, for the destruction of resisting objects, while its use as shrapnel, *i. e.*, for the attack of objects behind cover, should be regarded as secondary.

Ever since the appearance of the high explosive projectiles, we have given much attention to the consideration of their effects, and have made them the subject of analytical investigation, the results of which are here presented.

It is assumed that in construction the projectile is like a thick-walled shell, the wall of which is either a single piece or composed of two parts.

The geometrical relations of the space in which the fragments move resulting from the assumed construction of the projectiles, constitute the basis of the investigations; and it is assumed as a foundation for these relations that the projectile is a simple hollow cylinder, which is reasonable, since in the shrapnel effect considered in this study, only the fragments of the cylindrical portion can be regarded as effective.

The fragments of the projectile head and base are not taken into consideration at all; they constitute a sort of advance and rear guard, respectively, for the main body of fragments of the projectile body.

The fragments from the head have a velocity equal to that of the projectile increased by that imparted by the bursting charge, and therefore precede the fragments of the body; the fragments from the base, on the other hand, fall behind those of the body, since their velocity is that of the projectile diminished by that imparted by the bursting charge. If this difference is negative, the fragments will fly backward.

CALCULATION OF THE ANGLES AT THE APICES OF THE OUTER AND INNER CONES.

In order to determine geometrically the space within which the fragments of the body of the projectile move, we must first find an answer to the question: in what direction will any particular fragment of the body move out from the point of bursting of the projectile.

Let the velocity of the projectile at the instant of bursting be v in the direction of its motion of translation, its angular velocity of rotation ω, and let the bursting charge impart to the fragments the (average) velocity u. Then a fragment, the center of gravity of which is at a distance ρ from the longer axis of the projectile, will be affected by the three following velocities:

a. The velocity v in the direction of the tangent of the trajectory, which, when the angle between it and the longer axis of the projectile (angle of nutation) is very small, may be regarded as coinciding with this axis.

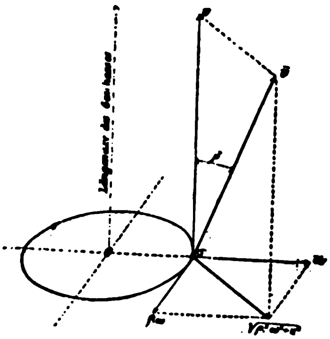
b. The tangential velocity $\rho . \omega$ in the plane (equatorial plane) through the center of gravity of the fragment perpendicular to the larger axis of the projectile.

c. The radial velocity u in the equatorial plane, perpendicular to the direction of the tangential velocity.

If we combine the three velocities v, $\rho . \omega$ and u, we have the resulting direction of motion of the fragment, of which only one element, viz: the angle β, which it makes with the tangent to the trajectory (or longer axis of the projectile), is of interest in the following investigations.

If we combine (Fig. 1) the velocities $\rho . \omega$ and u in the equatorial plane we have the partial resultant expression $\sqrt{\rho^2 . \omega^2 + u^2}$, which represents the projection of the resulting velocity $\overline{v}$ on the equatorial plane; this partial resultant combined with the velocity v gives the resultant $\overline{v}$, which makes the angle β with the line σv, representing the direction of the longer axis (tangent to the trajectory).

Fig ·



From the figure it is evident that

$$\tan \beta = \frac{\sqrt{\rho^2 . \omega^2 + u^2}}{v}. \qquad (1)$$

The angular velocity ω, if we neglect the friction of the air, is constant, or at least nearly so, and can therefore be readily computed from known elements.

Let n be the number of revolutions per second, then

$$\omega = n \, . \, 2\pi,$$

and since

$$n = \frac{\text{initial velocity}}{\text{absolute terminal twist}} = \frac{V}{L},$$

$$\omega = 2\pi \, . \, \frac{V}{L}.$$

From the known value of the angle of twist α

$$\tan \alpha = \frac{2 r \pi}{L},$$

in which r is the semi-caliber, the expression for ω becomes

$$\omega = \frac{V}{r} \, . \tan \alpha,$$

and equation (1)

$$\tan \beta = \frac{\sqrt{\left(\frac{\rho}{r}\right)^2 . V^2 \tan^2 \alpha + u^2}}{v} =$$

$$\sqrt{\left(\frac{\rho}{r}\right)^2 \left(\frac{V}{v}\right)^2 . \tan^2 \alpha + \left(\frac{u}{v}\right)^2} \qquad (1_1)$$

This expression shows that β increases with the final angle of twist, and also with the distance, since the ratios $\frac{V}{v}$ and $\frac{u}{v}$ increase as the distance increases; finally, other things remaining the same, *β increases with the distance of the fragment from the longer axis of the projectile.*

With the assistance of Poncelet's theorem relating to the square-root of the sum of two squares, equation (1_1) may be more simply expressed, if it is merely a question of an approximate determination of the value of β; and with the indeterminate character of the value of u, which differs in general for every fragment, nothing more than an approximation is possible.

Poncelet's theorem is, if the expression

$$R = \sqrt{P^2 + Q^2}$$

is to be solved, and $P > Q$. its value to within an error of 4% of its true value will be

$$R = 0.96\,P + 0.40\,Q.$$

Since, in equation (1_1), the second term under the radical is greater than the first, the approximate value for $\tan\beta$ is

$$\tan\beta = 0.96\frac{u}{v} + 0.40\,\frac{\rho}{r}\,.\,\frac{V}{v}\tan\alpha. \qquad (1_2)$$

If the disruption of the projectile were perfectly regular and constant,, and if, in addition, the limiting values of u were known, the limiting value of β, within which the lines of direction of the fragments must lie, could be accurately determined.

But, since the conditions enumerated are not fulfilled, we may regard as sufficiently accurate in practice the limiting values of β resulting from the substitutions

$$\rho = r, \text{ and } \rho = r - \delta,$$

in which δ is the thickness of the wall.

The *higher* limiting value of δ is therefore determined from

$$\tan\beta_1 = \sqrt{\left(\frac{V}{v}\right)^2 . \tan^2\alpha + \left(\frac{u}{v}\right)^2}, \text{ or} \qquad (1_1')$$

$$\tan\beta_1 = 0.96\frac{u}{v} + 0.40\,\frac{V}{v}\,.\tan\alpha\,; \qquad (1_2')$$

the *lower* from

$$\tan\beta_2 = \sqrt{\left(1 - \frac{\delta}{r}\right)^2 \left(\frac{V}{v}\right)^2 . \tan^2\alpha + \left(\frac{u}{v}\right)^2}, \text{ or} \qquad (1_1'')$$

$$\tan\beta_2 = 0.96\,\frac{u}{v} + 0.40\left(1 - \frac{\delta}{r}\right).\frac{V}{v}\,.\tan\alpha. \qquad (1_2'')$$

If from equation $(1_2')$ we subtract equation $(1_2'')$ the following relation, independent of u, will result:

$$\tan\beta_1 - \tan\beta_2 = 0.40\,.\,\frac{\delta}{r}\,.\,\frac{V}{v}\,.\tan\alpha.$$

With small differences between the angles β_1 and β_2 we may write

$$\tan\beta_1 - \tan\beta_2 = c(\beta_1 - \beta_2),$$

in which the factor c depends on the unit of measure of the angles, and on the region in which the angles β_1 and β_2 happen to fall.

If the angles are given in *degrees*, we may assume that between

0° and 10° $c = 0.0175$.
10° and 20° $c = 0.0187$.
20° and 30° $c = 0.0213$.
30° and 40° $c = 0.0262$.
40° and 50° $c = 0.0353$.
50° and 60° $c = 0.0540$.

We obtain, accordingly, as an approximate determination of the difference between the angles, the expression

$$\gamma = \beta_1 - \beta_2 = \frac{1}{c} \cdot 0.40 \cdot \frac{\delta}{r} \cdot \frac{V}{v} \cdot \tan \alpha.$$

If now we substitute for $\tan \alpha$ the approximate value

$$0.0175 \cdot \alpha^\circ.$$

we obtain

$$\gamma^\circ = \frac{0.007}{c} \cdot \frac{\delta}{r} \cdot \frac{V}{v} \cdot \alpha^\circ. \qquad (2)$$

γ, as we shall presently see, is the *angle of the hollow cone* (the angle between the two surfaces of the hollow cone).

We may take, as an empirical formula for the calculation of γ, the following

$$\gamma = C \cdot \frac{\delta}{r} \cdot \frac{V}{v} \alpha.$$

The value of u, which can only be regarded as an average value, may be determined directly by electro-ballistic measurement, or indirectly by taking the point of burst of the shrapnel and intercepting the fragments.

In the latter case β_1 may be found from the known geometrical relations, and then by means of equations ($1_1'$) or ($1_2'$) the value of u calculated.

In this way the well-known military writer, Major General Rohne,* found for the German high explosive shell (*Sprenggranate*) C/88 the value of $u = 400$ m.; β_1 is given as 55°, β_2 as 45°, from which it will follow that $\gamma = 10°$.

Based on these investigations it is easy to determine the surface in which the initial directions of the fragments lie.

In Figure 2 the body of the projectile is represented in longitudinal section; if through C_1 the right line $A_1 S_1$ be drawn making the angle β_1, through C_2 the right line $A_2 S_2$ making the angle β_2 with the larger axis of the projectile, and rotate the right lines $A_1 S_1$ and $A_2 S_2$ about the larger axis, we obtain the conical surfaces $A_1 S_1 B_1$ and $A_2 S_2 B_2$, with their apices at S_1 and S_2, between which the fragments of the body of the projectile move.

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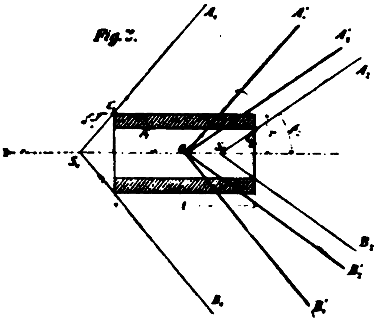
* See his *Schiesslehre für die Feld-Artillerie*, p. 106, et seq.

Fig. 2.



If we regard the center, O, of the body of the projectile of length l, as the bursting point of the shrapnel, then S_1 will be at a distance

$$OS_1 = \frac{l}{2} + r \cdot \tan \beta_1$$

behind the bursting point; and S_2, from the relations of the parts in the figure, at a distance

$$OS_2 = \frac{l}{2} - (r - \delta) \cdot \tan \beta_2$$

in front of this point.

The distance between the apices of the outer and inner cones is, therefore,

$$S_1 S_2 = S_1 O + O S_2 = l + r (\tan \beta_1 - \tan \beta_2) + \delta \cdot \tan \beta_2.$$

The generally accepted view that the fragments of the body of the projectile move in a hollow cone, the limiting conical surfaces of which have a common apex, is consequently incorrect; although —especially in view of the unavoidable errors in the determination of the exact location of the point of burst—it may be permitted to neglect the comparatively small distance $S_1 S_2$, and transfer the common apex of the two conical surfaces of the hollow cone to O, which means that the fragments move within the hollow cone $A_1' A_2' O B_2' B_1'$, an idea which we adopt in this discussion.

EQUATIONS OF THE CONICAL SURFACES; SECTIONS OF THE CONES WITH THE GROUND.

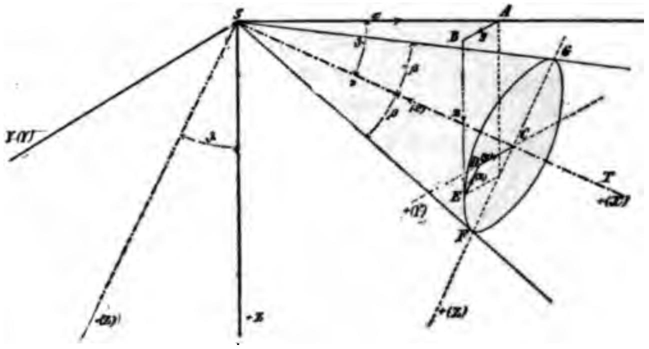
The geometrical relations of the cone of explosion being known, it is now merely a question of bringing the latter in relation with the target surface.

In Figure 3, let S represent the bursting point of the high explosive shell, ST the tangent to the trajectory, which is assumed to coincide with the longer axis of the projectile, then the two conical furfaces forming the hollow cone may be constructed, and let $SEFG$, with the angle at the apex equal to 2β, represent one of the two conical surfaces onder consideration.

The tangential angle ϑ is known from the angle of fall for the distance of the point of burst and the angle of position of the point of burst.

In order to simplify the solutions of the problems further on, it

Fig. 3.



is assumed that for a *group* of bursts the directions of gents to the trajectories) are *parallel.*

Of course, the trajectories of the fragments are cu they may be regarded as *right lines,* since, for effect behi only the fragments of *lower part of the hollow cone* with r short trajectories come into play, aside from the fac would be quite impossible, on account of the irregular the fragments, to determine the equations of their c motion.

The course pursued in the solution of the problem i lows: The equations of the conical surfaces are first det and then the latter are made to cut the target surface, t tion of which is also known.

To simplify matters the target surface is assumed to b zontal plane at a determined vertical distance H from of burst S.

We will now proceed to determine the equation of th surface.

As a preliminary system of coordinates, to which th surface may be referred and its equation at once writte us take that of $S\ (X)\ (Y)\ (Z)$, Fig. 3. The axis of $(X$ tangent to the trajectory, the axis of (Z) is perpendicul tangent to the trajectory, lying in the plane of fire, th (Y) is perpendicular to the plane of fire; the positive d along the axes are indicated in the figure by the + sign.

The equation of the conical surface expresses its prop the projections of the sections perpendicular to the axi $(Y)\ (Z)$ plane are circles with their centers at S, and variable radii $(x) \tan \beta$.

The equation for any one of the projections is

$$(y)^2 + (z)^2 = (x)^2 \, . \, \tan^2 \beta, \qquad (a)$$

which is also the equation of the conical surface.

The system of coordinates ultimately used is that of $S\,X\,Y\,Z$, Fig. 3. The axis of X is horizontal and makes with the axis (X) the tangential angle ϑ; the axis of Z is vertical and makes with (Z) an angle equal to ϑ; the axis of Y coincides with the axis (Y).

The determination of the equation of the conical surface referred to the system of coordinates $S\,X\,Y\,Z$ is therefore merely a matter of the transformation of coordinates.

This is most readily accomplished by the "theorem of projections."

In Figure 3 the coordinates of any point E of the conical surface referred to both systems of coordinates, are represented and connected by the closed series of lines $S\,A\,B\,E\,D\,C\,S$.

If we project this series of lines in order on the axes $(S(X)$, $S\,(Y)$ and $S\,(Z)$, then according to the theorem that the algebraic sum of the projections of the separate lengths must be equal to zero, the following transformation equations will result:

$$(x) = x \, . \cos \vartheta + z \, . \sin \vartheta;$$
$$(y) = y;$$
$$(z) = - \, x \, . \sin \vartheta + z \, . \cos \vartheta.$$

Now, if we substitute the values of (x), (y) and (z) from these equations in equation (a), we obtain the equation of the conical surface referred to the axes $S\,X\,Y\,Z$,

$$y^2 + (z \, . \cos \vartheta - x \, . \sin \vartheta)^2 = (x \, . \cos \vartheta + z \, . \sin \vartheta)^2 \tan^2 \beta. \quad (3)$$

If for β we substitute β_1 and β_2 we obtain the *equations of the outer and inner conical surfaces of the hollow cone*, respectively.

A simple test of the correctness of equation (3) will be to make the conical surface cut the plane $X\,Z$, the equation of which is

$$y = 0.$$

The equation of the section is determined from the simultaneous existence of the conditions expressed by the two last equations, together with

$$z \, . \cos \vartheta - x \sin \vartheta = \pm \, (x \, . \cos \vartheta + z \sin \vartheta) \, . \tan \beta,$$

from which, as may be readily shown, we have

$$z = x \, . \tan (\vartheta \pm \beta) \qquad (4)$$

i.e. the equation of the right line sections SF (or SG), which may also be derived directly from the figure.

Only the *upper* sign, *i. e.* the equation of the section SF (t
lowest element of the conical surface) is of importance to here.

Now, to find the grouping of the fragments on the targ surface, for which—in order to present only the general aspe of the problem—we select the simplest, *i. e.* a horizontal plan we have only to make the conical surfaces cut the plane whos equation is

$$z = H.$$

If we let this equation and equation (3) exist at the same time we will have the following equation of the section curve:

$$y^2 + (H \,.\, \cos \vartheta - x \,.\, \sin \vartheta)^2 = (x \,.\, \cos \vartheta + H \,.\, \sin \vartheta)^2 \tan^2 \beta, \quad (3$$

and by simple transformations,

$$x^2 (\sin^2 \vartheta - \cos^2 \vartheta \,.\, \tan^2 \beta) + y^2 - x \,.\, H \,.\, \frac{\sin 2 \vartheta}{\cos^2 \beta} + \\ H^2 (\cos^2 \vartheta - \sin^2 \vartheta \,.\, \tan^2 \beta) = 0. \quad (5.$$

In this we must substitute β_1 and β_2 for β in order to obtain th section curves for the outer and inner conical surfaces, respectively.

The section curve is, of course, a conical section, or curve of the second order, the nature of which is determined by the sign of the characteristic binominal.

Let us remind the reader that the curve represented by the equation

$$Ax^2 + 2\,Bxy + Cy^2 + 2\,Dx + 2\,Ey + F = 0 \qquad (b)$$

represents an hyperbola, ellipse or parabola, according as

$$\mathbf{B} = B^2 - AC \qquad (c)$$

is positive, negative or zero.

In the case before us

$$\mathbf{B} = -A = \cos^2 \vartheta \,.\, \tan^2 \beta - \sin^2 \vartheta = \cos^2 \vartheta \,(\tan^2 \beta - \tan^2 \vartheta), \quad (6)$$

therefore, and this is also evident from the figure itself, the section curve is an hyperbola, ellipse or parabola, according as

$$\beta > \vartheta, \ \beta < \quad \text{or } \beta = \vartheta.$$

The fragments of the body of the projectile will be found within the limits of a zone bordered by two curves of the second order, but of this only the portion nearest the point of burst has any part in our discussion.

The curves of the second order enclosing the zone may be of similar or of different character, depending on the relative values of β_1, β_2 and ϑ.

The horizontal distance a of the (nearer) vertex of the curve from the point of burst S may be found from equation (4), or, by placing $y = 0$, from equation (3); it is

$$a = \frac{H}{\tan(\beta + \vartheta)}. \qquad (7)$$

For the parabola we obtain from (5), when $\vartheta = \beta$, the special form

$$y^2 - 2xH . \tan\beta + H^2(1 - \tan^2\beta) = 0. \qquad (5_1)$$

If we consider the values of β_1, β_2 and ϑ, liable to arise in practice, we will find that we have always to do with the case

$$\beta > \vartheta;$$

in other words, the sections of the conical surfaces with the horizontal ground are always hyperbolas.

In the following discussion we will consider only equation (5), which may also be written as follows:

$$x^2 . \sin(\vartheta + \beta) . \sin(\vartheta - \beta) + y^2 . \cos^2\beta - x . H . \sin 2\vartheta + H^2 . \cos(\vartheta + \beta) . \cos(\vartheta - \beta) = 0. \qquad (5')$$

The determination of the elements of the curve, such as center, foci, length of principal axes, etc., which are of theoretical rather than of practical value, we will leave to the reader as a good exercise in the study of the equations of curves of the second order.

From equations (b) and (c) the coordinates of the center are

$$\xi = \frac{C . D - B . E}{B} \text{ and } \eta = \frac{A \quad E - B . D}{B},$$

and if we introduce from equation (5) the corresponding coefficients

$$\xi = -\frac{H}{2} . \frac{\sin 2\vartheta}{\sin(\beta + \vartheta) \ \sin(\beta - \vartheta)} \text{ and } \eta - 0 \text{ etc.}$$

The value of ξ may also be obtained directly by a transformation of coordinates such that the first power of x in equation (5) disappears.

In practice it is sufficient, by means of equation (5) or (5′), to find for assumed values of x the corresponding values of y, and thus construct the curves by points, as is illustrated in the following examples. The lower limit of the values of x is determined by means of equation (7).

Example 1.—Given $\beta_1 = 55°$, $\beta_2 = 45°$ and $\vartheta = 7°$ (assumed by Rohne in the work above mentioned).

It is required to give the equations of the limiting lines of the zone of dispersion.

From equations (5) and (5′) we obtain the equation for the *outer* hyperbola,

$$y^2 - 1.995\, x^2 - 0.735\, H \cdot x + 0.955\, H^2 = 0, \qquad (8$$

and for the *inner* hyperbola

$$y^2 - 0.970\, x^2 - 0.484\, H \cdot x + 0.970\, H^2 = 0. \qquad (8'')$$

Example 2.—What is the horizontal distance, in Example 1, of the vertices of the curves from the point of burst for $H = 1$ meter?

From equation 7 we have

$$a_1 = \cot 62° = 0.532 \text{ m.},$$
$$a_2 = \cot 52° = 0.781 \text{ m.}$$

For $H = 2, 3, 4 \ldots$ m., these values are multiplied by 2, 3, 4 . .

Example 3. In connection with examples 1 and 2, it is required to compute, for $H = 3$ m., several ordinates of the bounding curves of the zone of dispersion, and to construct the curves.

The vertices of the curves are (Example 2) at the following horizontal distances from the bursting point:

1.596 m. and 2.343 m., respectively, and are therefore
0.747 m. = 1 pace, apart.

For the *outer* hyperbola are to be computed the ordinates corresponding the abscissas

2.343, 4, 6, 8, 10 and 12 m.,

for the *inner* hyperbola the same—except the first, 2.343.

If we substitute $H = 3$ in equations (8′) and (8″) we have

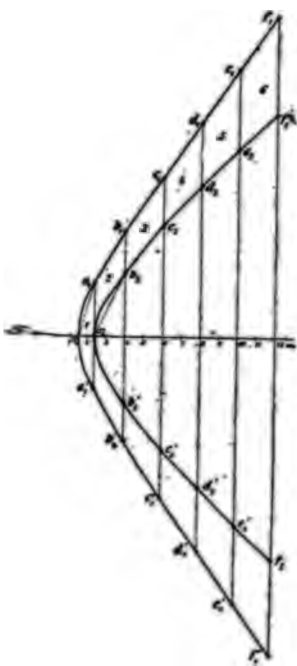
$$y_1 = \pm \sqrt{1.995\, x^2 + 2.205\, x - 8.595}, \text{ and}$$
$$y_2 = \pm \sqrt{0.970\, x^2 + 1.452\, x - 8.730},$$

in which the above values of the abscissas are to be substituted.

The results of the computation are given in the following table, and are represented graphically in Fig. 4. The table also gives the widths of the zones, the total widths of the surfaces and the total widths of the hollow interior space.

ABSCISSAS m.	1.596	2.343	4	6	8	10	12
Ordinates of outer hyperbola, (y_1) m.	0	2.74	5.67	8.74	11.69	14.58	17.47
Ordinates of inner hyperbola, (y_2) m	—	0	3.55	5.91	8.06	10.13	12.18
Width of zone $y_1 - y_2$)m . . .	—	2.74	2.12	2.83	3.63	4.45	5.29
Total width of surface ($2y_1$)m.	0	5.48	11.34	17.48	23.38	29.16	34.94
Total width of interior space ($2y_2$) m	—	—	7.10	11.82	16.12	20.26	24.36

Fig. 4



In case a pair of values, x and y, has been reliably determined, also the value of H, then β may be found from the following relation derived from equation (3_1):

$$\tan^2\beta = \frac{y_1 + H \cdot \cos\vartheta - x_1 \cdot \sin\vartheta)^2}{x_1 \cdot \cos\vartheta + H \cdot \sin\vartheta)^2} \qquad (9)$$

from which, as already indicated, conclusions as to the value of the radial velocity may be drawn. x_1 and y_1 denote any particular pair of values.

DETERMINATION OF THE NUMBER OF FRAGMENTS IN A PORTION OF THE ZONE OF DISPERSION LIMITED BY A PLANE PERPENDICULAR TO THE LINE OF FIRE.

In order to solve this problem, it is necessary first to determine the area of the zone of dispersion and then to find that portion of the body of the projectile from which fragments fall into this zone.

The area of the zone of dispersion may be determined by calculating, in Fig. 4, the areas of the hyperbola segments $f_1' \sigma_1 f_1$ and $f_2' \sigma_2 f_2$, and subtracting the latter from the former.

The calculation of the areas of the hyperbola segments is a simple problem in integration, which involves, however, complex formulas, not necessary in practice, especially when, as in this case, it is not a question of great mathematical accuracy.

For the mathematically instructed reader it will suffice to call attention to the fact that if we place

$$\alpha + \beta \cdot x + y \cdot x^2 = X,$$

then

$$\int dx \sqrt{X} = \frac{(\beta + 2\gamma \cdot x)\sqrt{X}}{4\gamma} + \frac{4\alpha\gamma - \beta^2}{8\gamma}\int\frac{x}{\sqrt{X}} + C,$$

and the value of the integral

$$\int\frac{dx}{\sqrt{X}}$$

can be found in any collection of formulas.

In practice it will suffice to compute the partial areas 1, 2 . . 6, in Fig. 4, by bounding them, as indicated in the figure, by right lines; the errors in the case of areas 1 and 2 evidently balance.

Example.—In connection with example 3 of the preceding section, let it be iequired to calculate the area of the zone of dispersion.

1 2 3 4 5 and 6

we find the areas

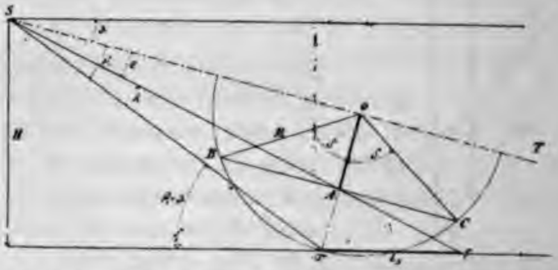
1.02 4.03 4.95 6.46 8.08 and 9.74 m.^{2},

therefore, for half the total area of dispersion 34.28 m^2., and for the entire surface 68.56 m^2.

The portion of the body of the projectile from which fragments fall on this surface is determined from the following considerations.

In Fig. 5 let $S\,T$ represent the axis of the cone of dispersion (tangent to the trajectory), $S\,\sigma$ the lowest element of the cone, and σf the depth (horizontally) of the zone of dispersion (Fig. 4), so that f is the projection on the vertical plane of $f_1 f_1'$, Fig. 4.

Fig. 5.



If through $f_1 f_1'$ and S we pass a plane, the trace of which on the vertical plane is Sf, Fig. 5, then all the fragments *below* this plane fall on the zone of dispersion.

If now through σ a section normal to the axis of the cone be taken, and the section figure—a circle—be revolved, then the angle at the center, 2δ, subtended by the chord $A\,C$, will determine the number of fragments Z_s of the zone of dispersion, this is, if n denote the total number of fragments of the body of the projectile,

$$Z_s = n \cdot \frac{\delta}{180}. \qquad (10)$$

The angle δ is determined when the angle ε and the radius $Bo = R$ are known.

For

$$\cos\delta = \frac{oA}{R}$$

and

$$oA = So \cdot \tan\varepsilon = S\sigma \cdot \cos\beta_1 \cdot \tan\varepsilon$$

$$= \frac{H}{\cos(\beta + \vartheta)} \cdot \cos\beta_1 \tan\varepsilon,$$

also

$$R = \sigma o = \frac{H}{\cos(\beta_1 + \vartheta)} \sin \beta_1$$

hence,

$$\cos \delta = \frac{\tan \varepsilon}{\tan \beta_1} = \frac{\tan(\beta_1 - \lambda)}{\tan \beta_1}. \qquad (11)$$

Finally, λ may be determined from the triangle $S\sigma f$, of which the two sides

$$S\sigma = \frac{H}{\cos(\beta_1 + \vartheta)} \text{ and } \sigma f = t_s,$$

and the enclosed angle

$$S\sigma f = 180 - (\beta_1 + \vartheta)$$

are known.

According to the well known rule λ is determined as follows:

$$\tan \lambda = \frac{t_s \cdot \sin(\beta_1 + \vartheta)}{\frac{H}{\cos(\beta_1 + \vartheta)} + t_s \cdot \cos(\beta_1 + \vartheta)} =$$

$$\frac{1}{2} \frac{t_s \cdot \sin 2(\beta_1 + \vartheta)}{H + t_s \cdot \cos^2(\beta_1 + \vartheta)} \qquad (12)$$

Example.—In connection with example 3 in the preceding section, it is required to determine what proportional part of the mass of the body of the projectile falls on the zone of dispersion considered.

If in equation (12) we substitute

$$t_s = 12 - 1.596 = 10.404,$$
$$\beta_1 = 55°, \ \vartheta = 7° \text{ and } H = 3 \text{ m.},$$

we will have

$$\lambda = 39° \ 10' \ 12'',$$

hence

$$\cos \delta = \frac{\tan[55° - (39° \ 10' \ 12'')]}{\tan 55°}, \text{ from which}$$

$$\delta = 78° \ 33' \ 10'' = 78°.5528.$$

From equation (10) we have, therefore,

$$Z_s = n \cdot \frac{78.5528}{180} = \frac{1}{2.29} n;$$

i.e. less than half the mass of the body of the projectile falls on the zone of dispersion considered.

For example, if the body of the projectile gives 300 fragments, 131 would fall on the zone of dispersion considered, therefore, from the preceding problem, on an average 1.9 fragments to a square meter.

Of course the distribution of the fragments will not b the *density* will be greater near the vertices, and wil rapidly from that region.

THE MOST FAVORABLE POSITION FOR THE MEAN POINT OF

In Fig. 6 *DD* represents the covering line and *MNP*(face to be struck, situated behind it.

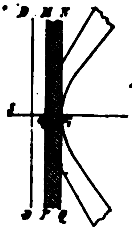


Fig. 6

From the fact that the densest groupi fragments is at σ_1 σ_2, the point of burst the most favorable position when the zo persion covers the target surface in th represented in the figure.

Larger areas of the zone of dispersior deed, be made to cover *MNPQ*, if the burst be put farther back; but the effec be increased, because a portion of the surface of disper densely charged with fragments is then replaced by o more lightly charged.

However, the position of *S*, in the relative positions (dispersion and target surface represented in Fig. 6, *mean* position of the point of burst, from which we can zontally forward or backward only the distance between $\sigma_1\sigma_2$. And this distance between vertices, as experien and as is evident from Fig. 5, is very small.

The most favorable position obtained for the point o a single shot must, for a group of shots, be converted *mean* point of burst.

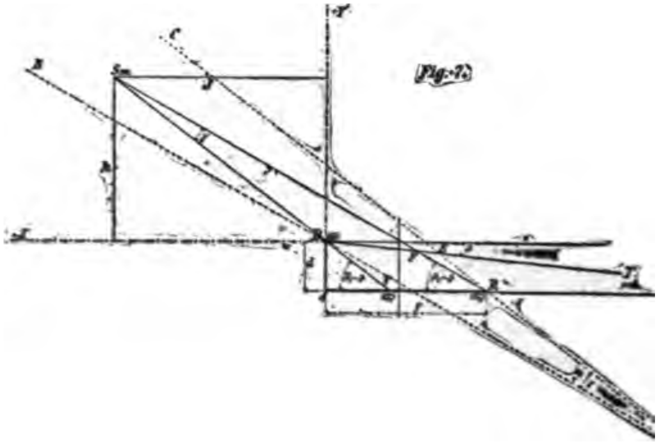


Fig. 7

In Fig. 7, let *DA* represent the cover and *AR* t surface behind it; $AD = d$, $AR = f$; the system of coordinates, XOY, has its origin at the crest of the parapet D.

If through D we pass a line making the angle $\beta_1 + \vartheta$ with the horizontal, then VR will be equal to the depth t_s of the target surface which can be struck, and the point of burst sought S_m will be on this line.

The point S_m, with the coordinates h and J, is also on the line RS_m passing through R with the inclination $\beta_2 + \vartheta$ to the horizon, so that $S_m \sigma_1 \sigma_2$ is the deepest vertical section through the apex—called *apex section* for short—of the cone of explosion.

The depth t_s is determined from

$$t_s = f - d \cdot \cot(\beta_1 + \vartheta). \tag{13}$$

In order to find the coordinates h and J, let the equations for the lines DS_m and RS_m exist simultaneously.

The equation of DS_m is

$$y = x \cdot \tan(\beta_1 + \vartheta),$$

and that of $S_m R$, determined by the point R and the inclination $\beta_2 + \vartheta$, is

$$y + d = (x + f) \tan(\beta_2 + \vartheta), \text{ or}$$
$$y = x \cdot \tan(\beta_2 + \vartheta) + f \cdot \tan(\beta_2 + \vartheta) - d.$$

If the equations of the two lines exist simultaneously we have

$$J = \frac{f \cdot \tan(\beta_2 + \delta) - d}{\tan(\beta_1 + \vartheta) - \tan(\beta_2 + \vartheta)}, \tag{14}$$

and

$$h = J \cdot \tan(\beta_2 + \vartheta). \tag{15}$$

Example.—Making the same assumptions as in the preceding examples, and taking $d = 1$ *m.*, and $f = 3$ *m.*, it is required to compute the values of t_s, J and h.

Remembering that $\beta_1 = 55°$, $\beta_2 = 45°$ and $\vartheta = 7°$, equation 13 gives

$$t_s = 3 - \cot 62° = 2.468 \text{ m.},$$

equation 14 gives

$$J = \frac{3 \cdot \tan 52° - 1}{\tan 62° - \tan 52°} = 4.72 \text{ m.},$$

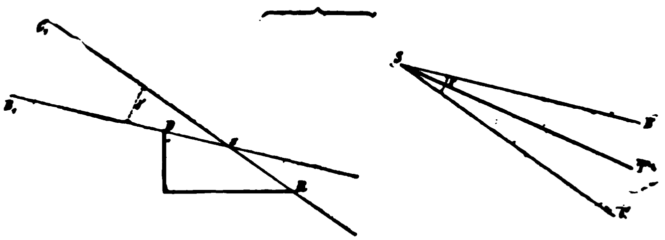
and equation 15 gives

$$h = 4.72 \cdot \tan 62° = 8.88 \text{ m.}$$

The relation of J to h is that of $\cot 62° = 0.532$.

Finally, to obtain a complete idea of the effectiveness, it may be required to determine the area in which the point of burst must lie, in order that the apex section can strike on the target surface.

Fig. 8.



A simple consideration will show that this area is enclosed by the line *DB* drawn through *D* parallel to the highest trajectory $S_m R$ of the apex section, and the line *RC* drawn through *R*, parallel to the lowest trajectory $S_m D$ of the apex section.

The position of the point *s* relative to *R* is evidently the same as that of the point S_m with reference to *D*.

Of course, for shrapnel effect, only those projectiles come into play which explode *above* the tangent to the trajectory drawn through the point *D*, *i. e.* in the space *B D E C*; the shrapnel in the space $S_m DT$ strike full on the deepest vertical axial section, those in the space BDS_m only partially.

Similar considerations lead to the determination of the space within which ordinary shrapnel must explode in order to be dangerous to a given target.

This is shown in Fig. 8.

ST is the direction of the tangent to the trajectory, *SB* and *SC* the highest and lowest elements, respectively, of the cone of dispersion.

Now, if DB_1 is drawn parallel to *SB*, and C_1R parallel to *S C*, we have the space B_1sC_1, in which the shrapnel must explode to have effective action.

In case of *round* bodies, like balloons, tangents must be drawn in place of grazing lines.

The determination of the point *s* is a simple matter: the equations of the grazing lines or tangents, as the case may be, are constructed, and are then made to coexist.

We will leave that to be done by the reader.

[Translated by 1st Lieutenant John P. Wisser,
First Artillery.]

The new ballistic table is based upon the new resistance formula, viz:

$$r = \frac{\delta i}{C} F(v),$$

in which

$$F(v) = 0.2002\,v - 48.05 + \sqrt{(0.1648\,v - 47.95)^2 + 9.6} + \frac{0.0442\,v\,(v-300)}{371 + \left(\frac{v}{200}\right)^{10}},$$

r = retardation, (or resistance per unit of mass) in metres,
v = velocity, in meters,
δ = weight in kilogrammes of a cubic metre of air divided by 1.206,
i = coefficient of form,
C = ballistic coefficient $= \frac{p}{1000\,a^2}$,
a and p = diameter and weight of the projectile in metres and kilogrammes.

This formula, by making $i = 1$, represents the results of the English and Russian experiments (Bashforth and Mayevski); and by making $i = 0.896$, represents the Dutch (Hojel) and those obtained at Meppen (Krupp).*

The functions,

$$D(u) = -\int \frac{u\,du}{F(u)}, \qquad J(u) = -\int \frac{2g\,du}{u\,F(u)},$$

$$F(u) = -\int \frac{du}{F(u)}, \qquad A(u) = -\int \frac{J(u)\,u\,du}{F(u)},$$

were calculated by quadratures.

In the first place, 101 values of $D(u)$ were calculated by Simpson's formula,

$$D(u + 2\Delta u) = D(u) + \frac{\Delta u}{3}\left[\frac{1}{F(u)} + \frac{4}{F(u + \Delta u)} + \frac{1}{F(u + 2\Delta u)}\right]$$

Placing $\Delta u = 12$, from $u =$ [illegible] to $u = 396$ metres,
Placing $\Delta u = 6$, from $u = 396$ to $u =$ [illegible] metres,
Placing $\Delta u = 3$, from $u =$ [illegible] to $u =$ [illegible] metres,

---

* See *Journal* May-June, 1897.

Placing $\Delta u = 2$, from $u = 180$ to $u = 120$ metres,
Placing $\Delta u = 1$, from $u = 120$ to $n = 96$ metres.

From these were obtained, by simple and quadratic interpolation, values of u corresponding to values of the argument $D(u)$ having a constant difference of 10.

By similar interpolations were obtained the values of

$$J(u) = -\int \frac{2g\,du}{uF(u)} = \int \frac{2g}{u^2} d \,.\, D(u),$$

$$T(u) = -\int \frac{du}{F(u)} = \int \frac{1}{u} d \,.\, D(u),$$

after having calculated the values of the two functions by Simpson's formula, with a constant difference of 50 in the values of $J(u)$.[*]

Finally the values of

$$A(u) = -\int J(u) \frac{u\,du}{F(u)} = \int J(u) d \,.\, D(u),$$

were all calculated by the trapezium formula without interpolation.

Formulas (22), (23), (24), of our second article on the resistance of the air[†] have been used as a check in those portions of the table relating to high velocities. For low velocities the well known formulas of quadratic resistance have served the same purpose.

As to medium velocities, we have made numerous applications of the general ballistic formulas, making use not only of the new table, but also of the old one published in our Ballistics, and have found only exceedingly slight differences in the results; the divergence between the numerical values of the resistance for medium velocities, as given by the old and new formulas, being very small.

For the initial values of D, J, A, T, we have taken respectively 1000, 0.1, 100, and 1; by adopting which the table may be extended considerably beyond the velocity 1500 metres without encountering negative values, although we are of the opinion

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[*] Placing

$$D(u) = z,\ J(u) = J(z),\ \frac{2g}{u^2} = f(z),$$

$$T(u) = T(z),\ \frac{1}{u} = k(z),$$

we have

$$J(z + 2\Delta z) = J(z) + \frac{\Delta z}{3}\Big[f(z) + 4f(z + \Delta z) + f(z + 2\Delta z)\Big],$$

$$T(z + 2\Delta z) = T(z) + \frac{\Delta z}{3}\Big[k(z) + 4k(z + \Delta z) + k(z + 2\Delta z)\Big].$$

[†] See *Journal* September-October, 1897.

that for practical calculations it will never be necessary to go beyond 1000 metres. On the other hand it must not be forgotten that the experimental velocities upon which the resistance formula is based do not exceed that limit; still we believe that a well extended ballistic table may be of considerable assistance in certain theoretical researches.

GENERAL BALLISTIC FORMULAS.

$$D(u) = D(V) + \frac{\delta i \beta}{C} x$$

$$y = x \operatorname{tg} \varphi - \frac{C}{2 \delta i \beta \cos^2 \varphi} \left[\frac{A(u) - A(V)}{D(u) - D(V)} - J(V) \right]$$

$$\operatorname{tg} \theta = \operatorname{tg} \varphi - \frac{C}{2 \delta i \beta \cos^2 \varphi} \left[J(u) - J(V) \right]$$

$$t = \frac{C}{\delta i \beta \cos \varphi} \left[T(u) - T(V) \right], \quad v = \frac{u \cos \varphi}{\cos \theta};$$

V, φ, x, y, θ, t, and v, are the muzzle velocity, angle of departure, abscissa, ordinate, inclination, time, and velocity; β may be taken as unity with sufficient accuracy when $\varphi < 20°$.

For greater angles a table giving values of β will shortly be published.

D	J	Diff.	A	Diff.	T	Diff.	*u*	Diff
1000	0.10000	8	100.000	1.000	1.000	6	1500.0	3.0
10	0.10008	9	101.000	1.001	1.006	6	1497.0	3.0
20	0.10017	9	102.001	1.003	1.012	7	1494.0	3.0
30	0.10026	9	103.004	1.003	1.019	6	1491.0	3.0
40	0.10035	9	104.007	1.004	1.025	7	1488.0	3.0
50	0.10044	9	105.011	1.004	1.032	7	1485.0	3.0
60	0.10053	9	106.015	1.006	1.039	7	1482.0	3.0
70	0.10062	9	107.021	1.007	1.046	7	1479.0	3.0
80	0.10071	9	108.028	1.007	1.053	7	1476.0	3.0
90	0.10080	9	109.035	1.009	1.060	7	1473.0	3.0
1100	0.10089	9	110.044	1.009	1.067	7	1470.0	3.0
10	0.10098	9	111.053	1.010	1.074	6	1467.0	3.0
20	0.10107	10	112.063	1.011	1.080	7	1464.0	3.0
30	0.10117	9	113.074	1.013	1.087	7	1461.0	3.0
40	0.10126	9	114.087	1.013	1.094	7	1458.0	3.0
50	0.10135	10	115.100	1.014	1.101	7	1455.0	3.0
60	0.10145	9	116.114	1.015	1.108	7	1452.0	3.0
70	0.10154	9	117.129	1.015	1.115	7	1449.0	3.0
80	0.10163	9	118.144	1.017	1.122	7	1446.0	3.0
90	0.10172	10	119.161	1.018	1.129	7	1443.0	3.0
1200	0.10182	9	120.179	1.019	1.136	7	1440.0	2.9
10	0.10191	9	121.198	1.020	1.143	7	1437.1	3.0
20	0.10201	9	122.218	1.021	1.150	7	1434.1	3.0
30	0.10210	10	123.239	1.021	1.157	7	1431.1	3.0
40	0.10220	9	124.260	1.022	1.164	7	1428.1	2.9
50	0.10229	10	125.282	1.024	1.171	7	1425.2	3.0
60	0.10239	9	126.306	1.024	1.178	7	1422.2	3.0
70	0.10248	10	127.330	1.025	1.185	7	1419.2	3.0
80	0.10258	10	128.355	1.026	1.192	7	1416.2	3.0
90	0.10268	10	129.381	1.028	1.199	7	1413.2	2.9
1300	0.10278	10	130.409	1.028	1.206	7	1410.3	3.0
10	0.10288	10	131.437	1.030	1.213	7	1407.3	2.9
20	0.10298	11	132.467	1.030	1.220	8	1404.4	3.0
30	0.10309	10	133.497	1.031	1.228	7	1401.4	2.9
40	0.10319	10	134.528	1.033	1.235	7	1398.5	3.0
50	0.10329	10	135.561	1.033	1.242	7	1395.5	2.9
60	0.10339	11	136.594	1.035	1.249	7	1392.6	3.0
70	0.10350	10	137.629	1.035	1.256	8	1389.6	3.0
80	0.10360	10	138.664	1.036	1.264	7	1386.6	2.9
90	0.10370	10	139.700	1.038	1.271	7	1383.7	3.0
1400	0.10380	11	140.738	1.039	1.278	7	1380.7	2.9
10	0.10391	10	141.777	1.039	1.285	8	1377.8	3.0
20	0.10401	10	142.816	1.041	1.293	7	1374.8	2.9
30	0.10411	11	143.857	1.041	1.300	8	1371.9	3.0
40	0.10422	10	144.898	1.043	1.308	7	1368.9	2.9
50	0.10432	11	145.941	1.044	1.315	7	1366.0	3.0
60	0.10443	10	146.985	1.045	1.322	8	1363.0	2.9
70	0.10453	11	148.030	1.046	1.330	7	1360.1	3.0
80	0.10464	10	149.076	1.047	1.337	7	1357.1	2.9
90	0.10474		150.123		1.344		1354.2	

D	J	Diff.	A	Diff.	T	Diff.	u	Diff.
00	0.10484	10	151.170	1.047	1.351	7	1351.2	3.0
10	0.10495	11	152.219	1.049	1.358	7	1348.3	2.9
20	0.10506	11	153.269	1 050	1.366	8	1345.3	3.0
30	0.10517	11	154.320	1.051	1.373	7	1342.4	2.9
40	0.10527	10	155.373	1.053	1.381	8	1339.5	2.9
50	0.10538	11	156.426	1.053	1.388	7	1336.5	3.0
60	0.10549	11	157.480	1.054	1.396	8	1333.6	2.9
70	0.10560	11	158.536	1.056	1.403	7	1330.7	2.9
80	0.10572	12	159.593	1.057	1.411	8	1327.8	2.9
90	0.10583	11	160.651	1.058	1.418	7	1324.9	2.9
600	0.10594	11	161.710	1.059	1.426	8	1321.9	3.0
10	0.10606	12	162.770	1.060	1.433	7	1319.0	2.9
20	0.10617	11	163.831	1.061	1.440	7	1316.1	2.9
30	0.10629	12	164.893	1.062	1 448	8	1313.2	2.9
40	0.10640	11	165.956	1.063	1.456	8	1310.3	2.9
50	0.10652	12	167.021	1.065	1.464	8	1307.3	3.0
60	0.10663	11	168.087	1.066	1.471	7	1304.4	2.9
70	0.10675	12	169.153	1.067	1.479	8	1301.5	2.9
80	0.10686	11	170.221	1.069	1.487	8	1298.6	2.9
90	0.10698	12	171.291	1.070	1.495	8	1295.7	2.9
700	0.10709	11	172.361	1.070	1.503	8	1292.7	3.0
10	0.10721	12	173.432	1.071	1.510	7	1289.8	2.9
20	0.10733	12	174.505	1.073	1.518	8	1286.9	2.9
30	0.10744	11	175.579	1.074	1.526	8	1284.0	2.9
40	0.10756	12	176.654	1.075	1.534	8	1281.1	2.9
50	0.10768	12	177.730	1.076	1.542	8	1278.2	2.9
60	0.10780	12	178.807	1.077	1.550	8	1275.3	2.9
70	0.10792	12	179.886	1.079	1.557	8	1272.4	2.9
80	0.10804	12	180.966	1.080	1.565	8	1269.5	2.9
90	0.10416	12	182.047	1.081	1.573	8	1266.6	2.9
800	0.10828	12	183.129	1.082	1.580	7	1263.8	2.9
10	0.10841	13	184.212	1.083	1.588	8	1260.9	2.9
20	0.10853	12	185.297	1.085	1.596	8	1258.0	2.9
30	0.10866	13	186.383	1.086	1.604	8	1255.1	2.9
40	0.10878	12	187.470	1.087	1.612	8	1252.2	2.9
50	0.10891	13	188.559	1.089	1.620	8	1249.3	2.9
60	0.10903	12	189.648	1.089	1.628	8	1246.4	2.9
70	0.10916	13	190.739	1.091	1.636	8	1243.5	2.9
80	0.10928	12	191.831	1.092	1.644	8	1240.6	2.9
90	0.10941	13	192.925	1.094	1.652	8	1237.7	2.9
1900	0.10954	13	194.020	1.095	1.660	8	1234.9	2.8
10	0.10967	13	195.116	1.096	1.668	8	1232.0	2.9
20	0.10980	13	196.213	1.097	1.676	8	1229.2	2.8
30	0.10993	13	197.312	1.099	1.684	8	1226.3	2.9
40	0.11006	13	198.412	1.100	1.693	9	1223.4	2.9
50	0.11020	14	199.513	1.101	1.701	8	1220.5	2.9
60	0.11033	13	200.616	1.103	1.709	8	1217.6	2.9
70	0.11046	13	201.720	1.104	1.717	8	1214.8	2.8
80	0.11059	13	202.825	1.105	1.726	9	1211.9	2.9
90	0.11072	13	203.932	1.107	1.734	8	1209.0	2.9

D	J	Diff.	A	Diff.	T	Diff.	u
2000	0.11086	14	205.040	1.108	1.743	9	1206.2
10	0.11100	14	206.150	1.110	1.751	8	1203.3
20	0.11113	13	207.260	1.110	1.759	8	1200.5
30	0.11127	14	208.372	1.112	1.767	8	1197.6
40	0.11141	14	209.485	1.113	1.775	8	1194.8
50	0.11155	14	210.600	1.115	1.784	9	1192.0
60	0.11168	13	211.716	1.116	1.792	8	1189.1
70	0.11182	14	212.834	1.118	1.800	8	1186.3
80	0.11196	14	213.953	1.119	1.809	9	1183.4
90	0.11210	14	215.074	1.121	1.817	8	1180.6
2100	0.11225	14	216.196	1.122	1.826	9	1177.8
10	0.11238	14	217.319	1.123	1.835	9	1174.9
20	0.11253	15	218.443	1.124	1.844	9	1172.1
30	0.11267	14	219.569	1.125	1.852	8	1169.3
40	0.11282	15	220.696	1.127	1.861	9	1166.5
50	0.11296	14	221.824	1.128	1.870	9	1163.7
60	0.11311	15	222.954	1.130	1.878	8	1160.8
70	0.11325	14	224.087	1.133	1.887	9	1158.0
80	0.11340	15	225.221	1.134	1.995	8	1155.2
90	0.11354	14	226.356	1.135	1.904	9	1152.4
2200	0.11369	15	227.492	1.136	1.912	8	1149.6
10	0.11384	15	228.629	1.137	1.921	9	1146.8
20	0.11399	15	229.767	1.138	1.930	9	1144.0
30	0.11414	15	230.908	1.141	1.939	9	1141.1
40	0.11429	15	232.050	1.142	1.948	9	1138.3
50	0.11444	15	233.194	1.144	1.956	8	1135.5
60	0.11460	16	234.339	1.145	1.965	9	1132.7
70	0.11475	15	235.486	1.147	1.974	9	1129.9
80	0.11490	15	236.634	1.148	1.983	9	1127.1
90	0.11506	16	237.784	1.150	1.992	9	1124.3
2300	0.11521	15	238.936	1.152	2.000	8	1121.5
10	0.11537	16	240.089	1.153	2.009	9	1118.7
20	0.11552	15	241.243	1.154	2.018	9	1115.9
30	0.11568	16	242.398	1.155	2.027	9	1113.2
40	0.11583	15	243.555	1.157	2.036	9	1110.4
50	0.11599	16	244.715	1.160	2.045	9	1107.6
60	0.11615	16	245.876	1.161	2.054	9	1104.8
70	0.11631	16	247.038	1.162	2.063	9	1102.0
80	0.11647	16	248.201	1.163	2.072	9	1099.2
90	0.11664	17	249.366	1.165	2.081	9	1096.4
2400	0.11680	16	250.534	1.168	2.091	10	1093.7
10	0.11696	16	251.703	1.169	2.100	9	1091.9
20	0.11712	16	252.874	1.171	2.109	9	1088.1
30	0.11729	17	254.046	1.172	2.118	9	1085.4
40	0.11745	16	255.220	1.174	2.128	10	1082.6
50	0.11762	16	256.395	1.175	2.137	9	1079.8
60	0.11779	17	257.572	1.177	2.146	9	1077.1
70	0.11796	17	253.751	1.179	2.156	10	1074.3
80	0.11814	18	259.932	1.181	2.165	9	1071.6
90	0.11831	17	261.114	1.182	2.174	9	1068.8

D	J	Diff.	A	Diff.	T	Diff.	*u*	Diff.
2500	0.11849	18	262.297	1.183	2.183	9	1066.1	2.7
10	0.11866	17	263.483	1.186	2.193	10	1063.4	2.7
20	0.11884	18	264.671	1.188	2.202	9	1060.6	2.8
30	0.11901	17	265.860	1.190	2.212	10	1057.9	2.7
40	0.11919	18	267.051	1.191	2.221	9	1055.1	2.8
50	0.11937	18	268.244	1.193	2.231	10	1052.4	2.7
60	0.11954	17	269.438	1.194	2.240	9	1049.7	2.7
70	0.11972	18	270.634	1.196	2.250	10	1046.9	2.8
80	0.11990	18	271.833	1.199	2.259	9	1044.2	2.7
90	0.12008	18	273.033	1.200	2.269	10	1041.4	2.8
2600	0.12026	18	274.235	1.202	2.278	9	1038.7	2.7
10	0.12045	19	275.438	1.204	2.288	10	1036.0	2.7
20	0.12063	18	276.643	1.205	2.298	10	1033.3	2.7
30	0.12082	19	277.851	1.208	2.308	10	1030.6	2.7
40	0.12101	19	279.060	1.209	2.317	9	1027.9	2.7
50	0.12119	18	280.270	1.210	2.327	10	1025.1	2.8
60	0.12138	19	281.484	1.214	2.337	10	1022.4	2.7
70	0.12157	19	282.699	1.215	2.347	10	1019.7	2.7
80	0.12176	19	283.915	1.216	2.357	10	1017.0	2.7
90	0.12195	19	285.134	1.219	2.366	9	1014.3	2.7
2700	0.12213	18	286.354	1.220	2.376	10	1011.6	2.7
10	0.12232	19	287.576	1.222	2.386	10	1008.9	2.7
20	0.12251	19	288.800	1.224	2.396	10	1006.2	2.7
30	0.12271	20	290.026	1.226	2.406	10	1003.5	2.7
40	0.12290	19	291.254	1.228	2.416	10	1000.8	2.7
50	0.12310	20	292.484	1.230	2.426	10	998.2	2.6
60	0.12330	20	293.717	1.233	2.436	10	995.5	2.7
70	0.12350	20	294.951	1.234	2.446	10	992.8	2.7
80	0.12369	19	296.187	1.236	2.456	10	990.1	2.7
90	0.12389	20	297.425	1.238	2.466	10	987.4	2.7
2800	0.12409	20	298.665	1.240	2.476	10	984.7	2.7
10	0.12430	21	299.907	1.242	2.487	11	982.1	2.6
20	0.12450	20	301.150	1.243	2.497	10	979.4	2.7
30	0.12471	21	302.396	1.246	2.507	10	976.7	2.7
40	0.12492	21	303.644	1.248	2.518	11	974.1	2.6
50	0.12513	21	304.894	1.250	2.528	10	971.4	2.7
60	0.12534	21	306.146	1.252	2.538	10	968.7	2.7
70	0.12555	21	307.401	1.255	2.548	10	966.1	2.6
80	0.12576	21	308.658	1.257	2.559	11	963.4	2.7
90	0.12696	20	309.917	1.259	2.569	10	960.8	2.6
2900	0.12617	21	311.178	1.261	2.579	10	958.1	2.7
10	0.12639	22	312.441	1.263	2.590	11	955.4	2.7
20	0.12661	22	313.706	1.265	2.600	10	952.8	2.6
30	0.12683	22	314.973	1.267	2.611	11	950.2	2.6
40	0.12705	22	316.242	1.269	2.621	10	947.5	2.7
50	0.12727	22	317.513	1.271	2.632	11	944.9	2.6
60	0.12749	22	318.787	1.274	2.642	11	942.3	2.6
70	0.12771	22	320.063	1.276	2.653	11	939.7	2.6
80	0.12793	22	321.341	1.278	2.664	11	937.1	2.6
90	0.12815	22	322.621	1.280	2.674	10	934.4	2.7

D	A	Diff.	A	Diff.	T	Diff.	*u*
3000	0.12837	22	323.904	1.283	2.685	11	931.8
10	0.12860	23	325.189	1.285	2.696	11	929.1
20	0.12882	22	326.476	1.287	2.709	10	926.5
30	0.12 04	22	327.766	1.290	2.717	11	923.9
40	0.12927	23	329.057	1.291	2.728	11	921.3
50	0.12950	23	330.351	1.294	2.739	11	918.7
60	1.12973	23	331.647	1.296	2.750	11	916.1
70	1.12997	24	332.946	1.299	2.761	11	913.5
80	1.13021	24	334.247	1.301	2.772	11	910.9
90	1.13045	24	335.550	1.303	2.783	11	908.3
3100	0.13069	24	336.856	1.306	2.794	11	905.7
10	0.13093	24	338.164	1.308	2.805	11	903.1
20	0.13118	25	339.474	1.310	2.816	11	900.5
30	0.13142	24	340.787	1.313	2.827	11	897.9
40	0.13166	24	342.102	1.315	2.839	12	895.4
50	0.13190	24	343.420	1.318	2.850	11	892.8
60	0.13215	25	344.740	1.320	2.861	11	890.2
70	0.13240	25	346.063	1.323	2.872	11	887.6
80	0.13265	25	347.388	1.325	2.883	11	885.0
90	0.13290	25	348.716	1.328	2.895	12	882.4
3200	0.13315	25	350.046	1.330	2.906	11	879.9
10	0.13341	26	351.378	1.332	2.917	11	877.3
20	0.13366	25	352.714	1.336	2.929	12	874.8
30	0.13392	26	354.052	1.338	2.940	11	872.2
40	0.13418	26	355.392	1.340	2.952	12	869.7
50	0.13444	26	356.735	1.343	2.963	11	867.1
60	0.13470	26	358.081	1.346	2.975	12	864.6
70	0.13496	26	359.429	1.348	2.986	11	862.0
80	0.13523	27	360.780	1.351	2.998	12	859.5
90	0.13549	26	362.134	1.353	3.009	11	856.9
3300	0.13576	27	363.490	1.356	3.021	12	854.4
10	0.13603	27	364.849	1.359	3.032	11	851.9
20	0.13630	27	366.211	1.362	3.044	12	849.4
30	0.13658	28	367.575	1.364	3.056	12	846.9
40	0.13685	27	368.942	1.367	3.068	12	844.4
50	0.13713	28	370.312	1.370	3.080	12	841.9
60	0.13740	27	371.685	1.373	3.092	12	839.4
70	0.13768	28	373.060	1.375	3.104	12	836.9
80	0.13796	28	374.438	1.378	3.116	12	834.4
90	0.13824	28	375.819	1.381	3.128	12	831.9
3400	0.13853	29	377.203	1.384	3.140	12	829.4
10	0.13881	28	378.590	1.387	3.152	12	827.0
20	0.13910	29	379.979	1.389	3.164	12	824.5
30	0.13939	29	381.372	1.393	3.176	12	822.0
40	0.13968	29	382.767	1.395	3.189	13	819.5
50	0.13998	30	384.166	1.399	3.201	12	817.1
60	0.14027	29	385.567	1.401	3.213	12	814.6
70	0.14057	30	386.971	1.404	3.225	12	812.1
80	0.14086	29	388.379	1.408	3.237	12	809.7
90	0.14116	30	389.789	1.410	3.250	13	807.2

D	J	Diff.	A	Diff.	T	Diff.	*u*	Diff.
3500	0.14147	31	391.202	1.413	3.262	12	804.7	2.5
10	0.14177	30	392.618	1.416	3.275	13	802.2	2.5
20	0.14208	31	394.037	1.419	3.288	13	799.8	2.4
30	0.14238	30	395.459	1·422	3.300	12	797.4	2.4
40	0.14269	31	396.885	1.426	3.313	13	793.9	2.5
50	0.14301	32	398.314	1.428	3.325	12	792.5	2.4
60	0.14332	31	399.745	1.431	3.338	13	790.0	2.5
70	0.14364	32	401.180	1.435	3.350	12	787.6	2.4
80	0.14395	31	402.618	1.438	3.363	13	785.2	2.4
90	0.14427	32	404.059	1.441	3.376	13	782.7	2.5
3600	0.14459	32	405.503	1.444	3.389	13	780.3	2.4
10	0.14491	32	406.950	1.447	3.402	13	777.9	2.4
20	0.14524	33	408.401	1.451	3.415	13	775.5	2.4
30	0.14557	33	409.856	1.455	3.428	13	773.1	2.4
40	0.14590	33	411.313	1.457	3.441	13	770.7	2.4
50	0.14624	34	412.774	1.461	3.454	13	768.3	2.4
60	0.14657	33	414.238	1.464	3.467	13	765.9	2.4
70	0.14690	33	415.705	1.467	3.480	13	763.5	2.4
80	0.14723	33	417.175	1.470	3.493	13	761.1	2.4
90	0.14757	34	418.649	1.474	3.506	13	758.7	2.4
3700	0.14791	34	420.127	1.478	3.519	13	756.3	2.4
10	0.14824	33	421.608	1.481	3.532	13	753.9	2.4
20	0.14858	34	423.092	1.484	3.545	13	751.5	2.4
30	0.14893	35	424.579	1.487	3.558	13	749.2	2.3
40	0.14928	35	426.070	1.491	3.572	14	746.8	2.4
50	0.14964	36	427.565	1.495	3.585	13	744.5	2.3
60	0.14999	35	429.063	1.498	3.598	13	741.1	2.4
70	0.15035	36	430.564	1.501	3.612	14	739.8	2.3
80	0.15071	36	432.070	1.506	3.625	13	737.4	2.4
90	0.15108	37	433.579	1.509	3.639	14	735.1	2.3
3800	0.15145	37	435.091	1.512	3.653	14	732.7	2.4
10	0.15182	37	436.607	1.516	3.666	13	730.4	2.3
20	0.15219	37	438.127	1.520	3.680	14	728.0	2.4
30	0.15257	38	439.651	1.524	3.694	14	725.7	2.3
40	0.15294	37	441.179	1.528	3.708	14	723.3	2.4
50	0.15331	37	442.710	1.531	3.722	14	721.0	2.3
60	0.15369	38	444.245	1.535	3.736	14	718.6	2.4
70	0.15407	38	445.784	1.539	3.750	14	716.3	2.3
80	0.15445	38	447.327	1.543	3.764	14	714.0	2.3
90	0.15484	39	448.873	1.546	3.778	14	711.7	2.3
3900	0.15523	39	450.424	1.551	3.792	14	709.4	2.3
10	0.15562	39	451.978	1.554	3.806	14	707.1	2.3
20	0.15601	39	453.536	1.558	3.820	14	704.7	2.4
30	0.15641	40	455.098	1.562	3.835	15	702.4	2.3
40	0.15680	39	456.664	1.566	3.849	14	700.1	2.3
50	0.15720	40	458.234	1.570	3.863	14	697.9	2.2
60	0.15760	40	459.809	1.575	3.878	15	695.6	2.3
70	0.15801	41	461.387	1.578	3.892	14	693.3	2.3
80	0.15843	42	462.969	1.582	3.906	14	691.1	2.2
90	0.15884	41	464.556	1.587	3.920	14	688.8	2·3

D	J	Diff.	A	Diff.	T	Diff.	*u*
4000	0.15925	41	466.146	1.590	3.935	15	686.6
10	0.15967	42	467.740	1.594	3.949	14	684.3
20	0.16009	42	469.339	1.599	3.964	15	682.1
30	0.16051	42	470.942	1.603	3.979	15	679.9
40	0.16094	43	472.549	1.607	3.993	14	677.6
50	0.16137	43	474.161	1.612	4.008	15	675.4
60	0.16180	43	475.777	1.616	4.023	15	673.2
70	0.16224	44	477.397	1.620	4.038	15	671.0
80	0.16267	43	469.022	1.625	4.053	15	668.8
90	0.16311	44	480.651	1.629	4.068	15	666.5
4100	0.16355	44	482.284	1.633	4.083	15	664.3
10	0.16399	44	483.922	1.638	4.098	15	662.1
20	0.16444	45	485.563	1.641	4.113	15	660.0
30	0.16489	45	487.210	1.647	4.129	16	657.8
40	0.16535	46	488.861	1.651	4.144	15	655.6
50	0.16581	46	490.517	1.656	4.159	15	653.4
60	0.16628	47	492.177	1.660	4.174	15	651.2
70	0.16674	46	493.843	1.666	4.190	16	649.0
80	0.16721	47	495.512	1.669	4.205	15	646.8
90	0.16768	47	497.186	1.674	4.220	15	644.6
4200	0.16815	47	498.865	1.679	4.236	16	642.5
10	0.16863	48	500.549	1.684	4.252	16	640.3
20	0.16911	48	502.238	1.689	4.267	15	638.2
30	0.16960	49	503.931	1.693	4.283	16	636.0
40	0.17009	49	505.630	1.699	4.299	16	633.9
50	0.17058	49	507.333	1.703	4.315	16	631.8
60	0.17108	50	509.041	1.708	4.331	16	629.7
70	0.17157	49	510.754	1.713	4.347	16	627.5
80	0.17207	50	512.473	1.719	4.363	16	625.4
90	0.17257	50	514.196	1.723	4.379	16	623.3
4300	0.17307	50	515.924	1.728	4.395	16	621.2
10	0.17358	51	517.657	1.733	4.412	17	619.1
20	0.17409	51	519.396	1.739	4.428	16	617.0
30	0.17461	52	521.139	1.743	4.444	16	614.9
40	0.17513	52	522.888	1.749	4.460	16	612.8
50	0.17562	52	524.642	1.754	4.476	16	610.8
60	0.17618	53	526.401	1.759	4.492	16	608.7
70	0.17671	53	528.165	1.764	4.509	17	606.6
80	0.17724	53	529.935	1.770	4.525	16	604.5
90	0.17778	54	531.718	1.775	4.542	17	602.4
4400	0.17832	54	533.499	1.780	4.558	16	600.4
10	0.17887	55	535.276	1.786	4.575	17	598.3
20	0.17942	55	537.068	1.792	4.592	17	596.3
30	0.17998	56	538.865	1.797	4.609	17	594.3
40	0.18054	56	540.667	1.802	4.626	17	592.2
50	0.18110	56	542.476	1.809	4.643	17	590.2
60	0.18166	56	544.289	1.813	4.660	17	588.1
70	0.18223	57	546.109	1.820	4.677	17	586.1
80	0.18280	57	547.934	1.825	4.694	17	584.1
90	0.18337	57	549.765	1.831	4.711	17	582.1

D	J	Diff.	A	Diff.	T	Diff.	*u*	Diff
4500	0.18395	58	551.602	1.837	4.728	17	580.1	2.0
10	0.18453	58	553.444	1.842	4.746	18	578.1	2.0
20	0.18512	59	555.292	1.848	4.763	17	576.1	2.0
30	0.18571	59	557.147	1.855	4.780	17	574.2	1.9
40	0.18631	60	559.007	1.860	4.798	18	572.2	2.0
50	0.18691	60	560.873	1.866	4.815	17	570.3	1.9
60	0.18752	61	562.745	1.872	4.833	18	568.3	2.0
70	0.18813	61	564.622	1.878	4.850	17	566.3	2.0
80	0.18875	62	566.508	1.885	4.868	18	564.4	1.9
90	0.18937	62	568.399	1.891	4.886	18	562.4	2.0
4600	0.18999	62	570.296	1.897	4.903	17	560.4	2.0
10	0.19062	63	572.199	1.903	4.921	18	558.4	2.0
20	0.19125	63	574.108	1.909	4.939	18	556.4	2.0
30	0.19189	64	576.023	1.915	4.957	18	554.5	1.9
40	0.19253	64	577.945	1.922	4.975	18	552.6	1.9
50	0.19317	64	579.874	1.929	4.994	19	550.8	1.8
60	0.19382	65	581.809	1.935	5.012	18	548.9	1.9
70	0.19447	65	583.750	1.941	5.030	18	547.0	1.9
80	0.19513	66	585.698	1.948	5.048	18	545.1	1.9
90	0.19579	66	587.653	1.955	5.066	18	543.2	1.9
4700	0.19645	66	589.614	1.961	5.085	19	541.3	1,9
10	0.19712	67	591.582	1.968	5.104	19	539.4	1.9
20	0.19780	68	593.556	1.974	5.122	18	537.5	1.9
30	0.19848	68	595.538	1.982	5.140	18	535.7	1.8
40	0.19917	69	597.526	1.988	5.159	19	533.8	1.9
50	0.19986	69	599.522	1.996	5.178	19	532.0	1.8
60	0.20056	70	601.524	2.002	5.197	19	530.1	1.9
70	0.20126	70	603.533	2.009	5.216	19	528.2	1.9
80	0.20196	70	605.549	2.016	5.235	19	526.4	1.8
90	0.20267	71	607.572	2.023	5.254	19	524.6	1.8
4800	0.20338	71	609.602	2.030	5.273	19	522.7	1.9
10	0.20410	72	611.640	2.038	5.293	20	520.9	1.8
20	0.20483	73	613.684	2.044	5.312	19	519.1	1.8
30	0.20556	73	615.736	2.052	5.331	19	517.3	1.8
40	0.20630	74	617.796	2.060	5.351	20	515.5	1.8
50	0.20704	74	619.862	2.066	5.370	19	513.7	1.8
60	0.20779	75	621.937	2.075	5.390	20	511.9	1.8
70	0.20854	75	624.018	2.081	5.409	19	510.1	1.8
80	0.20929	75	626.107	2.089	5.429	20	508.4	1.7
90	0.21005	76	628.214	2.097	5.449	20	506.6	1.8
4900	0.21081	76	630.308	2.104	5.468	19	504.8	1.8
10	0.21158	77	632.420	2.112	5.488	20	503.1	1.7
20	0.21236	78	634.540	2.120	5.508	20	501.4	1.7
30	0.21314	78	636.668	2.128	5.528	20	497.6	1.8
40	0.21393	79	638.803	2.135	5.548	20	499.9	1.7
50	0.21473	80	640.947	2.144	5.569	21	496.2	1.7
60	0.21553	80	643.098	2.151	5.589	20	494.5	1.7
70	0.21634	81	645.257	2.159	5.609	20	492.7	1.8
80	0.21715	81	647.425	2.168	5.629	20	491.0	1.7
90	0.21796	81	649.600	2.175	5.649	20	489.3	1.7

D	J	Diff.	A	Diff.	T	Diff.	*u*
5000	0.21878	82	651.784	2.184	5.669	20	487.6
10	0.21961	83	653.976	2.192	5.689	20	485.9
20	0.22045	84	656.176	2.200	5.710	21	484.2
30	0 22130	85	658.385	2.209	5.730	20	482.5
40	0.22215	85	660.602	2.217	5.751	21	480.8
50	0.22301	86	662.828	2.226	5.772	21	479.1
60	0.22386	85	665.062	2.234	5.793	21	477.5
70	0.22472	86	667.305	2.243	5.814	21	475.8
80	0.22558	86	669.556	2.251	5.835	21	474.2
90	0.22645	87	671.816	2.260	5.856	21	472.5
5100	0.22732	87	674.085	2.269	5.878	22	470.9
10	0.22820	88	676.362	2.277	5.899	21	469.3
20	0.22908	88	678.647	2.285	5.921	22	467.7
30	0.22997	89	680.942	2.295	5.942	21	466.1
40	0.23087	90	683.246	2.304	5.964	22	464.5
50	0.23178	91	685.559	2.313	5.985	21	462.9
60	0.23270	92	687.882	2.322	6.007	22	461.3
70	0.23364	94	690.214	2.332	6.028	21	459.7
80	0.23458	94	692.556	2.342	6.050	22	458.1
90	0.23553	95	694.906	2.350	6.072	22	456.5
5200	0.23648	95	697.266	2.360	6.094	22	455.0
10	0.23744	96	699.636	2.370	6.116	22	453.4
20	0.23840	96	702.015	2.379	6.138	22	451.9
30	0.23937	97	704.403	2.388	6.161	23	450.4
40	0.24034	97	706.801	2.398	6.183	22	448.8
50	0.24131	97	709.209	2.408	6.205	22	447.3
60	0.24229	98	711.627	2.418	6.227	22	445.8
70	0.24328	99	714.055	2.428	6.250	23	444.3
80	0.24427	99	716.493	2.438	6.272	23	442.8
90	0.24527	100	718.941	2.448	6.294	22	441.3
5300	0.24628	101	721.399	2.458	6.317	23	439.8
10	0.24729	101	723.867	2.468	6.340	23	438.3
20	0.24831	102	726.346	2.479	6.363	23	436.8
30	0.24934	103	728.835	2.489	6.386	23	435.3
40	0.25038	104	731.334	2.499	6.409	23	433.8
50	0.25142	104	733.844	2.510	6.433	24	432.4
60	0.25247	105	736.363	2.519	6.456	23	430.9
70	0.25353	106	738.893	2.530	6.479	23	429.5
80	0.25460	107	741.434	2.541	6.502	23	428.1
90	0.25568	108	743.985	2.551	6.525	23	426.7
5400	0.25677	109	746.55	2.552	6.549	24	425.2
10	0.25787	110	749.12	2.57	6.573	24	423.8
20	0.25897	110	751.70	2.58	6.596	23	422.4
30	0.26008	111	754.30	2.60	6.620	24	421.0
40	0.26120	112	756.91	2.61	6.643	23	419.6
50	0.26232	112	759.52	2.61	6.667	24	418.2
60	0.26344	112	762.15	2.63	6.691	24	416.8
70	0.26457	113	764.79	2.64	6.715	24	415.4
80	0.26571	114	767.44	2.65	6.739	24	414.0
90	0.26684	113	770.11	2.67	6.763	24	412.6

D	J	Diff.	A	Diff.	T	Diff.	*u*	Diff.
5500	0.26799	115	772.78	2.67	6.788	25	411.3	1.3
10	0.26915	116	775.47	2.69	6.812	24	409.9	1.4
20	0.27031	116	778.16	2.69	6.836	24	408.6	1.3
30	0.27148	117	780.87	2.71	6.861	25	407.3	1.3
40	0.27266	118	783.59	2.72	6.885	24	406.0	1.3
50	0.27385	119	786.33	2.74	6.910	25	404.7	1.3
60	0.27506	121	789.07	2.74	6.935	25	403.4	1.3
70	0.27627	121	791.83	2.76	6.960	25	402.1	1.3
80	0.27749	122	794.60	2.77	6.985	25	400.8	1.3
90	0.27872	123	797.38	2.78	7.010	25	399.5	1.3
5600	0.27996	124	800.17	2.79	7.035	25	398.2	1.3
10	0.28121	125	802.98	2.82	7.060	25	396.9	1.3
20	0.28246	125	805.80	2.82	7.085	25	395.6	1.3
30	0.28372	126	808.63	2.83	7.111	26	394.4	1.2
40	0.28599	127	811.47	2.84	7.136	25	393.1	1.3
50	0.28626	127	814.33	2.86	7.162	26	391.9	1.2
60	0.28754	128	817.20	2.87	7.188	26	390.7	1.2
70	0.28883	129	820.08	2.88	7.213	25	389.4	1.3
80	0.29012	129	822.98	2.90	7.239	26	388.2	1.2
90	0.29142	130	825.88	2.90	7.265	26	387.0	1.2
5700	0.29273	131	828.80	2.92	7.290	26	385.8	1.2
10	0.29405	132	831.74	2.94	7.317	27	384.6	1.2
20	0.29538	133	834.69	2.95	7.343	26	383.4	1.2
30	0.29672	134	837.65	2.96	7.369	26	382.2	1.2
40	0.29807	135	840.62	2.97	7.395	26	381.0	1.2
50	0.29942	135	843.61	2.99	7.421	26	379.9	1.1
60	0.30078	136	846.61	3.00	7.447	26	378.7	1.2
70	0.30215	137	849.62	3.01	7.474	27	377.6	1.1
80	0.30353	138	852.65	3.03	7.500	26	376.4	1.2
90	0.30492	139	855.69	3.04	7.526	26	375.3	1.1
5800	0.30632	140	858.75	3.06	7.553	27	374.1	1.2
10	0.30773	141	861.82	3.07	7.580	27	373.0	1.1
20	0.30914	141	864.90	3.08	7.606	26	371.9	1.1
30	0.31056	142	868.00	3.10	7.633	27	370.8	1.1
40	0.31199	143	871.12	3.12	7.660	27	369.7	1.1
50	0.31343	144	874.24	3.12	7.687	27	368.6	1.1
60	0.31488	145	877.38	3.14	7.714	27	367.5	1.1
70	0.31634	146	880.53	3.15	7.741	27	366.4	1.1
80	0.31781	147	883.70	3.17	7.769	28	365.3	1.1
90	0.31929	148	886.89	3.19	7.796	27	364.2	1.1
5900	0.32076	147	890.09	3.20	7.824	28	363.2	1.0
10	0.32225	149	893.30	3.21	7.871	27	362.1	1.1
20	0.32375	150	896.53	3.23	7.898	27	361.1	1.0
30	0.32526	151	899.78	3.25	7.926	28	360.0	1.1
40	0.32678	152	903.04	3.26	7.954	28	359.0	1.0
50	0.32831	153	906.31	3.27	7.982	28	358.0	1.0
60	0.32985	154	909.60	3.29	8.010	28	357.0	1.0
70	0.33139	154	912.91	3.31	8.038	28	356.0	1.0
80	0.33294	155	916.23	3.32	8.066	28	355.0	1.0
90	0.33450	156	919.57	3.34	8.095	29	354.1	0.9

D	J	Diff.	A	Diff.	T	Diff.	*u*
6000	0.33606	156	922.92	3.35	8.104	29	353.1
10	0.33763	157	926.29	3.37	8.132	28	352.1
20	0.33922	159	929.67	3.38	8.161	29	351.1
30	0.34081	159	933.07	3.40	8.189	28	350.2
40	0.34242	161	936.49	3.42	8.218	29	349.2
50	0.34403	161	939.92	3.43	8.247	29	348.2
60	0.34565	162	943.37	3.45	8.275	28	347.3
70	0.34728	163	946.84	3.47	8.304	29	346 4
80	0.34892	164	950.32	3.48	8.333	29	345.5
90	0.35057	165	953.81	3.49	8.362	29	344.6
6100	0.35223	166	957.33	3.52	8.391	29	343.7
10	0.35390	167	960.86	3.53	8.421	30	342.8
20	0.35557	167	964.41	3.55	8.450	29	341.9
30	0.35725	168	967.97	3.56	8.479	29	341.0
40	0.35894	169	971.55	3.58	8.509	30	340.1
50	0.36064	170	975.15	3.60	8.538	29	339.2
60	0.36235	171	978.76	3.61	8.568	30	338.4
70	0.36407	172	982.39	3.63	8.597	29	337.5
80	0.36580	173	986.04	3.65	8.627	30	336.6
90	0.36753	173	989.71	3.67	8.657	30	335.8
6200	0.36927	174	993.40	3.69	8.686	29	335.0
10	0.37102	175	997.10	3.70	8.716	30	334.2
20	0.37278	176	1000.82	3.72	8.746	30	333.4
30	0.37455	177	1004.55	3.73	8.776	30	332.6
40	0.37633	178	1008.31	3.76	8.806	30	331.8
50	0.37812	179	1012.08	3.77	8.837	31	331.0
60	0.37991	179	1015.87	3.79	8.867	30	330.2
70	0.38171	180	1019.68	3.81	8.897	30	329.4
80	0.38352	181	1023.50	3.82	8.927	30	328.6
90	0.38534	182	1027.35	3.85	8.957	30	327.9
6300	0.38717	183	1031.21	3.86	8.988	31	327.1
10	0.38901	184	1035.09	3.88	9.018	30	326.3
20	0.39086	185	1038.99	3.90	9.048	30	325.6
30	0.39272	186	1042.91	3.92	9.079	31	324.8
40	0.39458	186	1046.84	3.93	9.110	31	324.1
50	0.39645	187	1050.80	3.96	9.141	31	323.3
60	0.39833	188	1054.77	3.97	9.172	31	322.6
70	0.40022	189	1058.77	4.00	9.203	31	321.9
80	0.40212	190	1062.78	4.01	9.234	31	321.2
90	0.40402	190	1066.81	4.03	9.266	32	320.5
6400	0.40593	191	1070.86	4.05	9.297	31	319.8
10	0.40785	192	1074.93	4.07	9.328	31	319.1
20	0.40978	193	1079.02	4.09	9.359	31	318.5
30	0.41172	194	1083.12	4.10	9.391	32	317.8
40	0.41367	195	1087.25	4.13	9.422	31	317.1
50	0.41562	195	1091.40	4.15	9.454	32	316.4
60	0.41758	196	1095.56	4.16	9.485	31	315.8
70	0.41955	197	1099.75	4.19	9.517	32	315.1
80	0.42153	198	1103.95	4.20	9.549	32	314.5
90	0.42352	199	1108.18	4.23	9.581	32	313.8

D	J	Diff.	A	Diff.	T	Diff.	*u*	Diff.
6500	0.42552	200	1112.42	4.24	9.613	32	313.1	7
10	0.42753	201	1116.69	4.27	9.645	32	312.5	6
20	0.42955	202	1120.97	4.28	9.677	32	311.9	6
30	0.43157	202	1125.28	4.31	9.713	33	311.2	7
40	0.43360	203	1129.61	4.33	9.742	32	310.6	6
50	0.43564	204	1133.95	4.34	9.774	32	310.0	6
60	0.43768	204	1138.32	4.37	9.806	32	309.4	6
70	0.43973	205	1142.71	4.39	9.839	33	308.8	6
80	0.44179	206	1147.11	4.40	9.871	32	308.3	5
90	0.44386	207	1151.54	4.43	9.903	32	307.7	6
6600	0.44593	207	1155.99	4.45	9.936	33	307.1	6
10	0.44801	208	1160.46	4.47	9.968	32	306.5	6
20	0.45010	209	1164.95	4.49	10.001	33	305.9	6
30	0.45220	210	1169.46	4.51	10.034	33	305.4	5
40	0.45431	211	1173.99	4.53	10.066	32	304.8	6
50	0.45642	211	1178.55	4.56	10.099	33	304.2	6
60	0.45854	212	1183.12	4.57	10.132	33	303.7	5
70	0.46067	213	1187.72	4.60	10.165	33	303.1	6
80	0.46281	214	1192.34	4.62	10.198	33	302.5	6
90	0.46496	215	1196.98	4.64	10.231	33	302.0	5
6700	0.46712	216	1201.64	4.66	10.265	34	301.5	5
10	0.46928	216	1206.32	4.68	10.298	33	301.0	5
20	0.47145	217	1211.02	4.70	10.331	33	300.5	5
30	0.47363	218	1215.75	4.73	10.364	33	299.9	6
40	0.47582	219	1220.49	4.74	10.398	34	299.4	5
50	0.47801	219	1225.26	4.77	10.431	33	298.9	5
60	0.48021	220	1230.05	4.79	10.465	34	298.4	5
70	0.48241	220	1234.87	4.82	10.498	33	297.9	5
80	0.48462	221	1239.70	4.83	10.532	34	297.4	5
90	0.48684	222	1244.56	4.86	10.565	33	296.9	5
6800	0.48906	222	1249.44	[illegible]	[illegible]	34	296.4	5
10	0.49129	223	1254.34	[illegible]	10.633	34	295.9	5
20	0.49354	225	[illegible]	[illegible]	[illegible]	34	[illegible]	4
30	0.49579	225	[illegible]	[illegible]	[illegible]	34	[illegible]	5
40	0.49805	226	[illegible]	[illegible]	[illegible]	33	[illegible]	[illegible]
50	0.50031	226	[illegible]	[illegible]	[illegible]	34	[illegible]	[illegible]
60	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
70	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4
80	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
90	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6900	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
40	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
60	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
70	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
80	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
90	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

D	J	Diff.	A	Diff.	T	Diff.	*u*	Diff.
7000	0.53517	238	1351.81	5.34	11.285	35	287.3	4
10	0.53755	238	1357.18	5.37	11.320	35	286.9	4
20	0.53994	239	1362.56	5.38	11.355	35	286.5	4
30	0.54233	239	1367.98	5.42	11.390	35	286.1	4
40	0.54473	240	1373.41	5.43	11.425	35	285.7	4
50	0.54713	240	1378.87	5.46	11.459	34	285.2	5
60	0.54954	241	1384.35	5.48	11.494	35	284.8	4
70	0.55196	242	1389.86	5.51	11.529	35	284.4	4
80	0.55439	243	1395.39	5.53	11.564	35	284.0	4
90	0.55682	243	1400.95	5.56	11.600	36	283.6	4
7100	0.55926	244	1406.53	5.58	11.635	35	283.2	4
10	0.56171	245	1412.13	5.60	11.670	35	282.8	4
20	0.56417	246	1417.76	5.63	11.705	35	282.4	
30	0.56663	246	1423.42	5.66	11.741	36	282.0	
40	0.56910	247	1429.10	5.68	11.776	35	281.6	
50	0.57157	247	1434.80	5.70	11.812	36	281.3	
60	0.57405	248	1440.53	5.73	11.848	36	280.9	
70	0.57654	249	1446.28	5.75	11.883	35	280.5	
80	0.57903	249	1452.06	5.78	11.919	36	280.1	
90	0.58653	250	1457.86	5.80	11.955	36	279.7	
7200	0.58404	251	1463.69	5.83	11.991	36	279.3	
10	0.58656	252	1469.54	5.85	12.027	36	279.0	
20	0.58909	253	1475.42	5.88	12.063	36	278.6	
30	0.59162	253	1481.32	5.90	12.099	36	278.2	
40	0.59416	254	1487.25	5.93	12.135	36	277.8	
50	0.59670	254	1493.21	5.96	12.170	35	277.4	
60	0.59925	255	1499.19	5.98	12.206	36	277.0	4
70	0.60181	256	1505.19	6.00	12.242	36	276.6	4
80	0.60437	256	1511.22	6.03	12.278	36	276.2	4
90	0.60694	257	1517.28	6.06	12.314	36	275.8	4
7300	0.60952	258	1523.36	6.08	12.351	37	275.5	3
10	0.61211	259	1529.47	6.11	12.387	36	275.1	4
20	0.61471	260	1535.60	6.13	12.423	36	274.7	4
30	0.61731	260	1541.76	6.16	12.459	36	274.3	4
40	0.61992	261	1547.95	6.19	12.496	37	273.9	4
50	0.62254	262	1554.16	6.21	12.532	36	273.6	3
60	0.62516	262	1560.40	6.24	12.569	37	273.2	4
70	0.62779	263	1566.67	6.27	12.606	37	272.8	4
80	0.63043	264	1572.96	6.29	12.643	37	272.5	3
90	0.63307	264	1579.27	6.31	12.680	37	272.1	4
7400	0.63672	265	1585.62	6.35	12.717	37	271.7	4
10	0.63837	265	1591.99	6.37	12.754	37	271.3	4
20	0.64103	266	1598.39	6.40	12.791	37	271.0	3
30	0.64370	267	1604.81	6.42	12.828	37	270.6	4
40	0.64638	268	1611.26	6.45	12.865	37	270.3	3
50	0.64907	269	1617.74	6.48	12.902	37	269.9	4
60	0.65177	270	1624.24	6.50	12.939	37	269.5	4
70	0.65448	271	1630.77	6.53	12.976	37	269.2	3
80	0.65719	271	1637.33	6.56	13.013	37	268.8	4
90	0.65991	272	1643.92	6.59	13.050	37	268.5	3

D	J	Diff.	A	Diff.	T	Diff.	*u*	Diff.
500	0.66264	273	1650.53	6.61	13.087	37	268.1	4
10	0.66537	273	1657.17	6.64	13.125	38	267.8	3
20	0.66811	274	1663.84	6.67	13.162	37	267.4	4
30	0.67086	275	1670.53	6.69	13.199	37	267.1	3
40	0.67362	276	1677.25	6.72	13.236	37	266.7	4
50	0.67638	276	1684.00	6.75	13.274	38	266.4	3
60	0.67915	277	1690.78	6.78	13.312	38	266.0	4
70	0.68192	277	1697.59	6.81	13.350	38	265.7	3
80	0.68470	278	1704.42	6.83	13.388	38	265.3	4
90	0.68749	279	1711.28	6.86	13.426	38	265.0	3
600	0.69028	279	1718.17	6.89	13.463	37	264.6	4
10	0.69308	280	1725.09	6.92	13.501	38	264.3	3
20	0.69589	281	1732.03	6.94	13.539	38	263.9	4
30	0.69871	282	1739.00	6.97	13.577	38	263.6	3
40	0.70154	283	1746.01	7.01	13.615	38	263.2	4
50	0.70437	283	1753.04	7.03	13.653	38	262.9	3
60	0.70721	284	1760.09	7.05	13.691	38	262.5	4
70	0.71006	285	1767.18	7.09	13.729	38	262.2	3
80	0.71292	286	1774.29	7.11	13.767	38	261.8	4
90	0.71579	287	1781.44	7.13	13.805	38	261.5	3
700	0.71866	287	1788.61	7.17	13.843	38	261.1	4
10	0.72154	288	1795.81	7.20	13.882	39	260.8	3
20	0.72443	289	1803.04	7.23	13.920	38	260.4	4
30	0.72733	290	1810.30	7.26	13.958	38	260.1	3
40	0.73023	290	1817.59	7.29	13.997	39	259.8	3
50	0.73314	291	1824.90	7.31	14.036	39	259.4	4
60	0.73606	292	1832.25	7.35	14.074	38	259.1	3
	0.73898	292	1839.63	7.38	14.113	39	258.8	3
	0.74191	293	1847.03	7.40	14.152	39	258.4	4
	0.74485	294	1854.46	7.43	14.191	39	258.1	3
00	0.74780	295	1861.93	7.47	14.229	38	257.7	4
10	0.75075	295	1869.42	7.49	14.268	39	257.4	3
20	0.75371	296	1876.94	7.52	14.307	39	257.1	3
30	0.75668	297	1884.49	7.55	14.346	39	256.7	4
40	0.76966	298	1892.05	7.59	14.385	39	256.4	3
50	0.76264	298	1899.69	7.61	14.424	39	256.1	3
60	0.76563	299	1907.33	7.64	14.463	39	255.8	3
70	0.76863	300	1915.00	7.67	14.502	39	255.5	3
80	0.77164	301	1922.70	7.70	14.541	39	255.1	4
90	0.77466	302	1930.43	7.73	14.580	39	254.8	3
900	0.77769	303	1938.19	7.76	14.619	39	254.5	3
10	0.78072	303	1945.99	7.80	14.659	40	254.2	3
20	0.78376	304	1953.81	7.82	14.698	39	253.9	3
30	0.78681	305	1961.66	7.84	14.738	40	253.5	4
40	0.78987	306	1969.54	7.88	14.778	40	253.2	3
50	0.79293	306	1977.46	7.92	14.817	39	252.9	3
60	0.79600	307	1985.40	7.96	14.857	40	252.6	3
70	0.79908	308	1993.38	7.98	14.897	40	252.3	3
80	0.80216	308	2001.39	8.01	14.936	39	251.9	4
90	0.80525	309	2009.42	8.03	14.976	40	251.6	3

D	J	Diff.	A	Diff.	T	Diff.	*u*	Diff.
8000	0.80835	310	2017.49	8.07	15.015	39	251.3	3
10	0.81145	310	2025.59	8.10	15.055	40	251.0	3
20	0.81456	311	2033.72	8.13	15.095	40	250.7	3
30	0.81768	312	2041.88	8.16	15.135	40	250.3	4
40	9.82081	313	2050.07	8.19	15.174	39	250.0	3
50	0.82395	314	2058.30	8.23	15.214	40	249.7	3
60	0.82710	315	2066.55	8.25	15.254	40	249.4	3
70	0.83026	316	2074.84	8.29	15.294	40	249.1	3
80	0.83343	317	2083.16	8.32	15.334	40	248.7	4
90	0.83661	318	2091.51	8.35	15.374	40	248.4	3
8100	0.83980	319	2099.80	8.38	15.414	40	248.1	3
10	0.84299	319	2108.30	8.41	15.455	41	247.8	3
20	0.84619	320	2116.75	8.44	15.495	40	247.5	3
30	0.84940	321	2125.23	8.48	15.535	40	247.2	3
40	0.85261	321	2133.74	8.51	15.576	41	246.8	4
50	0.85583	322	2142.28	8.54	15.617	41	246.5	3
60	0.85906	323	2150.85	8.57	15.657	40	246.2	3
70	0.86230	324	2159.46	8.61	15.698	41	245.9	3
80	0.86555	325	2168.10	8.64	15.739	41	245.6	3
90	0.86781	326	2176.77	8.67	15.780	41	245.3	3
8200	0.87207	326	2185.48	8.71	15.820	40	245.0	3
10	0.87534	327	2194.21	8.73	15.861	41	244.6	4
20	0.87862	328	2202.98	8.77	15.902	41	244.3	3
30	0.88191	329	2211.79	8.81	15.943	41	244.0	3
40	0.88521	330	2220.62	8.83	15.984	41	243.7	3
50	0.88852	331	2229.49	8.87	16.025	41	243.4	3
60	0.89183	331	2238.39	8.90	16.066	41	243.1	3
70	0.89515	332	2247.32	8.93	16.107	41	242.8	3
80	0.89848	333	2256.29	8.97	16.148	41	242.5	3
90	0.90182	334	2265.30	9.01	16.189	41	242.2	3
8300	0.90517	335	2274.33	9.03	16.230	41	241.9	3
10	0.90853	336	2283.40	9.07	16.272	42	241.5	4
20	0.91189	336	2292.50	9.10	16.313	41	241.2	3
30	0.91526	337	2301.64	9.14	16.354	41	240.9	3
40	0.91864	338	2310.81	9.17	16.396	42	240.6	3
50	0.92203	339	2320.01	9.19	16.437	41	240.3	3
60	0.92543	340	2329.25	9.24	16.479	42	240.0	3
70	0.92884	341	2338.52	9.27	16.521	42	239.7	3
80	0.93226	342	2347.82	9.30	16.563	42	239.4	3
90	0.93569	343	2357.16	9.34	16.605	42	239.1	3
8400	0.93913	344	2366.54	9.35	16.647	42	238.8	3
10	0.94257	344	2375.95	9.41	16.689	42	238.5	3
20	0.94602	345	2385.39	9.44	16.731	42	238.2	3
30	0.94948	346	2394.87	9.48	16.773	42	237.9	3
40	0.95295	347	2404.38	9.51	16.815	42	237.6	3
50	0.95643	348	2413.93	9.55	16.857	42	237.3	3
60	0.95992	349	2423.51	9.58	16.900	43	237.0	3
70	0.96341	349	2433.12	9.61	16.942	42	236.7	3
80	0.96691	350	2442.78	9.66	16.984	42	236.4	3
90	0.97042	351	2452.46	9.68	17.026	42	236.1	3

D	J	Diff.	A	Diff.	T	Diff.	*u*	Diff.
500	0.97394	352	2462.18	9.72	17.068	43	235.8	3
10	0.97747	353	2471.94	9.76	17.010	42	235.5	3
20	0.98101	354	2481.73	9.79	17.053	43	235.3	3
30	0.98456	355	2491.56	9.83	17.096	43	235.0	3
40	0.98812	356	2501.42	9.86	17.138	42	234.7	3
50	0.99169	357	2511.32	9.90	17.181	43	234.4	3
60	0.99526	357	2521.26	9.94	17.223	42	234.1	3
70	0.99884	358	2531.23	9.97	17.266	43	233.8	3
80	1.00249	359	2541.23	10.00	17.309	43	233.5	3
90	1.00603	360	2561.28	10.05	17.351	43	233.2	3
600	1.00964	361	2561.36	10.08	17.494	43	232.9	3
10	1.01326	362	2571.47	10.11	17.537	43	232.6	3
20	1.01689	363	2581.62	10.13	17.580	43	232.4	2
30	1.02053	364	2591.81	10.19	17.624	44	232.1	3
40	1.02418	365	2602.03	10.22	17.667	43	231.8	3
50	1.02784	366	2612.29	10.26	17.710	43	231.5	3
60	1.03150	366	2622.59	10.30	17.754	44	231.2	3
70	1.03517	367	2632.92	10.33	17.797	43	230.9	3
80	1.03885	368	2643.29	10.37	17.840	43	230.6	3
90	1.04254	369	2653.70	10.41	17.884	44	230.3	3
700	1.04624	370	2664.14	10.44	17.927	43	230.0	3
10	1.04995	371	2674.62	10.48	17.971	44	229.7	3
20	1.05367	372	2685.14	10.52	18.015	44	229.5	2
30	1.05740	373	2695.70	10.56	18.058	43	229.2	3
40	1.06114	374	2706.29	10.59	18.102	44	228.9	3
50	1.06489	375	2716.92	10.63	18.145	43	228.6	3
60	1.06865	376	2727.59	10.67	18.189	44	228.3	3
70	1.07242	377	2738.29	10.70	18.233	44	228.0	3
80	1.07620	378	2749.04	10.75	18.277	44	227.7	3
90	1.07998	378	2759.82	10.78	18.321	44	227.5	3
800	1.08377	379	2770.64	10.82	18.364	43	227.2	3
10	1.08757	380	2781.49	10.85	18.408	44	226.9	3
20	1.09138	381	2792.39	10.90	18.452	44	226.6	3
30	1.09520	382	2803.32	10.93	18.497	45	226.3	3
40	1.09903	383	2814.29	10.97	18.541	44	226.0	3
50	1.10287	384	2825.30	11.01	18.585	44	225.8	2
60	1.10672	385	2836.35	11.05	18.629	44	225.5	3
70	1.11059	387	2847.44	11.09	18.674	45	225.2	3
80	1.11447	388	2858.56	11.12	18.718	44	224.9	3
90	1.11836	389	2869.73	11.17	18.763	45	224.6	3
3 900	1.12225	389	2880.93	11.20	18.807	44	224.3	3
10	1.12615	390	2892.17	11.24	18.852	45	224.1	2
20	1.13006	391	2903.45	11.28	18.897	45	223.8	3
30	1.13398	392	2914.77	11.32	18.942	45	223.5	3
40	1.13791	393	2926.13	11.36	18.986	44	223.2	3
50	1.14185	394	2937.53	11.40	19.031	45	222.9	3
60	1.14580	395	2948.97	11.44	19.076	45	222.6	3
70	1.14976	396	2960.45	11.48	19.121	45	222.4	2
80	1.15373	397	2971.96	11.51	19.166	45	222.1	3
90	1.15771	398	2983.52	11.56	19.211	45	221.8	3

D	J	Diff.	A	Diff.	T	Diff.	u	Diff.
9000	1.16171	400	2995.12	11.60	19.256	45	221.5	3
10	1.16571	400	3006.75	11.63	19.301	45	221.3	2
20	1.16972	401	3018.43	11.68	19.347	46	221.0	3
30	1.17374	402	3030.15	11.72	19.392	45	220.7	3
40	1.17777	403	3041.91	11.76	19.438	46	220.4	3
50	1.18181	404	3053.70	11.79	19.483	45	220.1	3
60	1.18586	405	3065.54	11.84	19.529	46	219.9	2
70	1.18992	406	3077.42	11.88	19.574	45	219.6	3
80	1.19399	407	3089.34	11.92	19.620	46	219.3	3
90	1.19808	409	3101.30	11.96	19.665	45	219.0	3
9100	1.20218	410	3113.30	12.00	19.710	45	218.8	2
10	1.20628	410	3125.35	12.05	19.756	46	218.5	3
20	1.21039	411	3137.43	12.08	19.802	46	218.2	3
30	1.21451	412	3149.55	12.12	19.848	46	217.9	3
40	1.21864	413	3161.72	12.17	19.894	46	217.7	2
50	1.22278	414	3173.93	12.21	19.940	46	217.4	3
60	1.22693	415	3186.17	12.24	19.986	46	217.1	3
70	1.23110	417	3198.46	12.29	20.032	46	216.9	2
80	1.23528	418	3210.80	12.34	20.078	46	216.6	3
90	1.23947	419	3223.17	12.37	20.124	46	216.3	3
9200	1.24367	420	3235.59	12.42	20.170	46	216.1	2
10	1.24788	421	3248.04	12.45	20.217	47	215.8	3
20	1.25210	422	3260.54	12.50	20.263	46	215.5	3
30	1.25633	423	3273.09	12.55	20.309	46	215.3	2
40	1.26057	424	3285.67	12.58	20.356	47	215.0	3
50	1.26482	425	3298.30	12.63	20.402	46	214.7	3
60	1.26908	426	3310.97	12.67	20.449	47	214.5	2
70	1.27335	427	3323.68	12.71	20.495	46	214.2	3
80	1.27762	427	3336.43	12.75	20.542	47	213.9	3
90	1.28190	428	3349.23	12.80	20.589	47	213.7	2
9300	1.28620	430	3362.07	12.84	20.636	47	213.4	3
10	1.29051	431	3374.96	12.89	20.684	48	213.2	2
20	1.29483	432	3387.88	12.92	20.731	47	212.9	3
30	1.29916	433	3400.85	12.97	20.778	47	212.6	3
40	1.30350	434	3413.87	13.02	20.825	47	212.4	2
50	1.30785	435	3426.92	13.05	20.872	47	212.1	3
60	1.31222	437	3440.02	13.10	20.919	47	211.9	2
70	1.31660	438	3453.17	13.15	20.966	47	211.6	3
80	1.32099	439	3466.35	13.18	21.013	47	211.4	2
90	1.32539	440	3479.59	13.24	21.060	47	211.1	3
9400	1.32980	441	3492.86	13.27	21.107	47	210.8	3
10	1.33422	442	3506.18	13.32	21.155	48	210.6	2
20	1.33865	443	3519.55	13.37	21.202	47	210.3	3
30	1.34309	444	3542.96	13.41	21.250	48	210.1	2
40	1.34754	445	3546.41	13.45	21.298	48	209.8	3
50	1.35200	446	3559.91	13.50	21.346	48	209.5	3
60	1.35647	447	3573.45	13.54	21.394	48	209.3	2
70	1.36095	448	3587.04	13.59	21.442	48	209.0	3
80	1.36544	449	3600.67	13.63	21.490	48	208.8	2
90	1.36994	450	3614.34	13.67	21.537	47	208.5	3

D	J	Diff.	A	Diff.	T	Diff.	*u*	Diff.
9500	1.37447	451	3628.07	13.73	21.585	48	208.3	2
10	1.37900	453	3641.83	13.76	21.634	49	208.0	3
20	1.38354	454	3655.65	13.82	21.682	48	207.8	2
30	1.38809	455	3669.50	13.85	21.730	48	207.5	3
40	1.39265	456	3683.41	13 91	21.778	48	207.3	2
50	1.39722	457	3697.36	13.95	21.827	47	207.0	3
60	1.40180	458	3711.35	13.99	21.875	48	206.8	2
70	1.40639	459	3725.39	14.04	21.923	48	206.5	3
80	1.41099	460	3739 48	14.09	21.971	48	206.3	2
90	1.41560	461	3753.61	14.13	22.020	49	206.0	3
9600	1.42022	462	3767 79	14.18	22.068	48	205.8	2
10	1.42486	464	3782.02	14.23	22.117	49	205.5	3
20	1.42951	465	3796.29	14.27	22.166	49	205.3	2
30	1.43417	466	3810.61	14.32	22.215	49	205.0	3
40	1.43884	467	3824.97	14.36	22.264	49	204.8	2
50	1.44352	468	3839.38	14.41	22.312	48	204.5	3
60	1.44821	469	3853.84	14.46	22.361	49	204.3	2
70	1.45292	471	3868.35	14.51	22.410	49	204.0	3
80	1.45764	472	3882.90	14.55	22.459	49	203.8	2
90	1.46237	473	3897.50	14.60	22.508	49	203.5	3
9700	1.46711	474	3912.15	14.65	22.557	49	203.3	2
10	1.47187	476	3926.84	14.69	22.607	50	203.0	3
20	1.47664	477	3941.59	14.75	22.656	49	202.8	2
30	1.48142	478	3956.38	14.79	22.706	50	202.5	3
40	1 48621	479	3971.21	14.83	22.755	49	202.3	2
50	1.49101	480	3986.10	14.89	22.804	49	202.0	3
60	1.49582	481	4001.04	14.94	22.853	49	201.8	2
70	1.50064	482	4016.02	14.98	22.903	50	201.5	3
80	1.50547	483	4031.04	15.02	23.953	50	201.3	2
90	1.51031	484	4046.13	15.09	23.002	49	201.0	3
9800	1.51516	485	4061.25	15.12	23.052	50	200.8	2
10	1.52003	487	4076.43	15.18	23.102	50	200.5	3
20	1.52491	488	4091.65	15.22	23.152	50	200.3	2
30	1.52980	489	4106.93	15.28	23.202	50	200.0	3
40	1.53471	491	4122.25	15.32	23.252	50	199.8	2
50	1.53963	492	4137.62	15.37	23.302	50	199.5	3
60	1.54456	493	4153.04	15 42	23.352	50	199.3	2
70	1.54951	495	4168.51	15.47	23.403	51	199.0	3
80	1.55447	496	4184 03	15.52	23.453	50	198.8	2
90	1.55944	497	4199.60	15.57	23.503	50	198.5	3
9900	1.56443	499	4215.22	15.62	23.553	50	198.3	2
10	1.56943	500	4230.89	15.67	23.604	51	198.0	3
20	1.57444	501	4246.61	15.72	23.654	50	197.8	2
30	1.57946	502	4262.38	15.77	23.705	51	197.5	3
40	1.58449	503	4278.20	15.82	23.755	50	197.3	2
50	1.58953	504	4294.07	15.87	23.806	51	197.1	2
60	1.59458	505	4309.99	15.92	23.857	51	196.8	3
70	1.59964	506	4325.96	15.97	23.908	51	196.6	2
80	1.60472	508	4341.98	16.02	23.958	50	196.4	2
90	1.60981	509	4358.06	16.08	24.009	51	196.1	3

D	J	Diff.	A	Diff.	T	Diff.	*u*	Diff.
10000	1.61491	510	4374.18	16.12	24.060	51	195.9	2
10	1.62003	512	4390.35	16.17	24.111	51	195.7	2
20	1.62516	513	4406.58	16.23	24.163	52	195.4	3
30	1.63030	514	4422.86	16.28	24.214	51	195.2	2
40	1.63545	515	4439.19	16.33	24.265	51	194.9	3
50	1.64062	517	4455.57	16.38	24.316	51	194.7	2
60	1.64580	518	4472.00	16.43	24.368	52	194.4	3
70	1.65099	519	4488.48	16.48	24.419	51	194.2	2
80	1.65619	520	4505.02	16.54	24.471	52	194.0	2
90	1.66141	522	4521.61	16.59	24.522	51	193.7	3
10100	1.66664	523	4538.25	16.64	24.574	52	193.5	2
10	1.67189	525	4554.94	16.69	24.626	52	193.2	3
20	1.67715	526	4571.69	16.73	24.678	52	193.0	2
30	1.68242	527	4588.48	16.79	24.730	52	192.7	3
40	1.68770	528	4605.53	16.85	24.781	51	192.5	2
50	1.69300	530	4622.24	16.91	24.833	52	192.3	2
60	1.69831	531	4639.20	16.96	24.885	52	192.0	3
70	1.70363	532	4656.21	17.01	24.937	52	191.8	2
80	1.70896	533	4673.27	17.06	24.989	52	191.6	2
90	1.71431	535	4690.38	17.11	25.041	52	191.3	3
10200	1.71967	536	4707.55	17.18	25.094	53	191.1	2
10	1.72505	538	4724.78	17.23	25.146	52	190.9	2
20	1.73044	539	4742.05	17.27	25.198	52	190.6	3
30	1.73585	541	4759.39	17.34	25.251	53	190.4	2
40	1.74127	542	4776.77	17.38	25.303	52	190.2	2
50	1.74670	543	4794.21	17.44	25.356	53	189.9	3
60	1.75214	544	4811.70	17.49	25.409	53	189.7	2
70	1.75760	546	4829.25	17.55	25.462	53	189.5	2
80	1.76307	547	4846.86	17.61	25.515	53	189.2	3
90	1.76855	548	4864.51	17.65	25.568	53	189.0	2
10300	1.77404	549	4882.23	17.72	25.621	53	188.8	2
10	1.77955	551	4900.00	17.77	25.675	54	188.5	3
20	1.78507	552	4917.82	17.82	25.728	53	188.3	2
30	1.79061	554	4935.70	17.88	25.781	53	188.1	2
40	1.79616	555	4953.63	17.93	25.834	53	187.8	3
50	1.80172	556	4971.62	17.99	25.888	54	187.5	2
60	1.80730	558	4989.67	18.05	25.941	53	187.4	2
70	1.81289	559	5007.77	18.10	25.994	53	187.1	3
80	1.81850	561	5025.92	18.15	26.047	53	186.9	2
90	1.82412	562	5044.14	18.22	26.100	53	186.7	2
10400	1.82976	564	5062.41	18.27	26.154	54	186.4	3
10	1.83541	565	5080.73	18.32	26.208	54	186.2	2
20	1.84107	566	5099.11	18.38	26.261	53	186.0	2
30	1.84674	567	5117.55	18.44	26.315	54	185.8	2
40	1.85243	569	5136.04	18.49	26.369	54	185.5	3
50	1.85814	571	5154.60	18.56	26.423	54	185.3	2
60	1.86386	572	5173.21	18.61	26.477	54	185.1	2
70	1.86959	573	5191.88	18.67	26.531	54	184.9	2
80	1.87534	575	5210.60	18.72	26.585	54	184.6	3
90	1.88110	576	5229.39	18.79	26.639	54	184.4	2

D	J	Diff.	A	Diff.	T	Diff.	*u*	Diff.
10500	1.88688	578	5248.23	18.84	26.693	54	184.2	2
10	1.89270	579	5267.12	18.89	26.747	54	184.0	2
20	1.89850	580	5286.08	18.96	26.802	55	183.7	3
30	1.90431	581	5305.09	19.01	26.856	54	183.5	2
40	1.91013	582	5324.17	19.08	26.911	55	183.3	2
50	1.91597	584	5343 30	19.13	26.966	55	183.1	2
60	1.92182	585	5362.49	19.19	27.020	54	182.8	3
70	1.92769	587	5381.73	19.24	27.075	55	182.6	2
80	1.93358	589	5401.04	19.31	27.130	55	182.4	2
90	1.93948	590	5420.40	19.36	27.185	55	182.2	2
10600	1.94538	592	5439.83	19.43	27.240	55	182.0	2
10	1.95131	593	5459.31	19.48	27.295	55	181.8	2
20	1.95725	594	5478.85	19.54	27.350	55	181.5	3
30	1.96320	595	5498.46	19.61	27.406	56	181.3	2
40	1.96911	597	5518.12	19.66	27.461	55	181.1	2
50	1.97515	598	5537.84	19.72	27.516	55	180.9	2
60	1.98115	600	5557.62	19.78	27.571	55	180.7	2
70	1.98716	601	5577.46	19.84	27.626	55	180.5	2
80	1.99319	603	5597.37	19.91	27.681	55	180.2	3
90	1.99924	605	5617.33	19.96	27.737	56	180.0	2
10700	2.00530	606	5637.35	20.02	27.792	55	179.8	2
10	2.01138	608	5657.43	20.08	27.848	56	179.6	2
20	2.01747	609	5677.58	20.15	27.904	56	179.4	2
30	2.02357	610	5697.78	20.20	27.960	56	179.1	3
40	2.02969	612	5718.05	20.27	28.016	56	178.9	2
50	2.03582	613	5738.38	20.33	28.072	56	178.7	2
60	2.04196	615	5758.77	20.39	28.128	56	178.5	2
70	1.04313	616	5779.22	20.45	28.184	56	178.3	2
80	2.05431	618	5799.73	20.51	28.240	56	178.0	3
90	2.06051	620	5820.30	20.57	28.296	56	177.8	2
10800	2.06672	621	5840.94	20.64	28.352	56	177.6	2
10	2.07295	623	5861.64	20.70	28.408	56	177.4	2
20	2.07919	624	5882.40	20.76	28.465	57	177.2	2
30	2.08544	625	5903.22	20.82	28.521	56	177.0	2
40	2.09171	627	5924.11	20.89	28.578	57	176.7	3
50	2.09800	629	5745.05	20.94	28.634	56	176.5	2
60	2.10430	630	5966.07	21,02	28.691	57	176.3	2
70	2.11062	632	5987.14	21.07	28.748	57	176.1	2
80	2.11695	633	6008.28	21.14	28.805	57	175.8	3
90	2.12330	635	6029.48	21.24	28.862	57	175.6	2
10900	2.12967	637	6050.74	21.26	28.919	57	175.4	2
10	2.13605	638	6072.07	21.33	29.077	58	175.2	2
20	2.14245	640	6093.47	21.40	29.034	57	175.0	2
30	2.14887	642	6114.92	21.45	29.091	57	174.8	2
40	2.15530	643	6136.44	21.52	29.148	57	174.6	2
50	2.16174	644	6158.03	21.59	29.206	58	174.4	2
60	2.16820	646	6179.68	21.65	29.263	57	174.1	3
70	2.17467	647	6201.39	21.71	29.320	57	173.9	2
80	2.18115	648	6223.17	21.78	29.377	57	173.7	2
90	2.18765	650	6245.02	21.85	29.434	57	173.5	2

D	J	Diff.	A	Diff.	T	Diff.	*u*	D
9000	1.16171	400	2995.12	11.60	19.256	45	221.5	
10	1.16571	400	3006.75	11.63	19.301	45	221.3	
20	1.16972	401	3018.43	11.68	19.347	46	221.0	
30	1.17374	402	3030.15	11.72	19.392	45	220.7	
40	1.17777	403	3041.91	11.76	19.438	46	220.4	
50	1.18181	404	3053.70	11.79	19.483	45	220.1	
60	1.18586	405	3065.54	11.84	19.529	46	219.9	
70	1.18992	406	3077.42	11.88	19.574	45	219.6	
80	1.19399	407	3089.34	11.92	19.620	46	219.3	
90	1.19808	409	3101,30	11.96	19.665	45	219.0	
9100	1.20218	410	3113.30	12.00	19.710	45	218.8	
10	1.20628	410	3125.35	12.05	19.756	46	218.5	
20	1.21039	411	3137.43	12.08	19.802	46	218.2	
30	1.21451	412	3149.55	12.12	19.848	46	217.9	
40	1.21864	413	3161.72	12.17	19.894	46	217.7	
50	1.22278	414	3173.93	12.21	19.940	46	217.4	
60	1.22693	415	3186.17	12.24	19.986	46	217.1	
70	1.23110	417	3198.46	12.29	20.032	46	216.9	
80	1.23528	418	3210.80	12.34	20.078	46	216.6	
90	1.23947	419	3223.17	12.37	20.124	46	216.3	
9200	1.24367	420	3235.59	12.42	20.170	46	216.1	
10	1.24788	421	3248.04	12.45	20.217	47	215.8	
20	1.25210	422	3260.54	12.50	20.263	46	215.5	
30	1.25633	423	3273 09	12.55	20.309	46	215.3	
40	1.26057	424	3285.67	12.58	20.356	47	215.0	
50	1.26482	425	3298.30	12.63	20.402	46	214.7	
60	1.26908	426	3310.97	12.67	20.449	47	214.5	
70	1.27335	427	3323.68	12.71	20.495	46	214.2	
80	1.27762	427	3336.43	12.75	20.542	47	213.9	
90	1.28190	428	3349.23	12.80	20.589	47	213.7	
9300	1.28620	430	3362.07	12.84	20.636	47	213.4	
10	1.29051	431	3374.96	12.89	20.684	48	213.2	
20	1.29483	432	3387.88	12.92	20.731	47	212.9	
30	1.29916	433	3400.85	12.97	20.778	47	212.6	
40	1.30350	434	3413.87	13.02	20 825	47	212.4	
50	1.30785	435	3426 92	13.05	20.872	47	212.1	
60	1.31222	437	3440.02	13.10	20.919	47	211.9	
70	1.31660	438	3453.17	13.15	20.966	47	211.6	
80	1.32099	439	3466.35	13.18	21.013	47	211.4	
90	1.32539	440	3479.59	13 24	21.060	47	211.1	
9400	1.32980	441	3492.86	13.27	21.107	47	210.8	
10	1.33422	442	3506.18	13.32	21.155	48	210.6	
20	1.33865	443	3519.55	13.37	21.202	47	210.3	
30	1.34309	444	3542.96	13.41	21.250	48	210.1	
40	1.34754	445	3546.41	13.45	21.298	48	209.8	
50	1.35200	446	3559.91	13 50	21.346	48	209.5	
60	1.35647	447	3573.45	13.54	21.394	48	209.3	
70	1.36095	448	3587.04	13.59	21.442	48	209.0	
80	1.36544	449	3600.67	13 63	21.490	48	208.8	
90	1.36994	450	3614.34	13.67	21.537	47	208.5	

D	J	Diff.	A	Diff.	T	Diff.	*u*	Diff
9500	1.37447	451	3628.07	13.73	21.585	48	208.3	2
10	1.37900	453	3641.83	13.76	21.634	49	208.0	3
20	1.38354	454	3655.65	13.82	21.682	48	207.8	2
30	1.38809	455	3669.50	13.85	21.730	48	207.5	3
40	1.39265	456	3683.41	13.91	21.778	48	207.3	2
50	1.39722	457	3697.36	13.95	21.827	47	207.0	3
60	1.40180	458	3711.35	13.99	21.875	48	206.8	2
70	1.40639	459	3725.39	14.04	21.923	48	206.5	3
80	1.41099	460	3739.48	14.09	21.971	48	206.3	2
90	1.41560	461	3753.61	14.13	22.020	49	206.0	3
9600	1.42022	462	3767.79	14.18	22.068	48	205.8	2
10	1.42486	464	3782.02	14.23	22.117	49	205.5	3
20	1.42951	465	3796.29	14.27	22.166	49	205.3	2
30	1.43417	466	3810.61	14.32	22.215	49	205.0	3
40	1.43884	467	3824.97	14.36	22.264	49	204.8	2
50	1.44352	468	3839.38	14.41	22.312	48	204.5	3
60	1.44821	469	3853.84	14.46	22.361	49	204.3	2
70	1.45292	471	3868.35	14.51	22.410	49	204.0	3
80	1.45764	472	3882.90	14.55	22.459	49	203.8	2
90	1.46237	473	3897.50	14.60	22.508	49	203.5	3
9700	1.46711	474	3912.15	14.65	22.557	49	203.3	2
10	1.47187	476	3926.84	14.69	22.607	50	203.0	3
20	1.47664	477	3941.59	14.75	22.656	49	202.8	2
30	1.48142	478	3956.38	14.79	22.706	50	202.5	3
40	1.48621	479	3971.21	14.83	22.755	49	202.3	2
50	1.49101	480	3986.10	14.89	22.804	49	202.0	3
60	1.49582	481	4001.04	14.94	22.853	49	201.8	2
70	1.50064	482	4016.02	14.98	[illegible]	50	201.5	3
80	1.50547	483	4031.04	15.02	[illegible]	50	[illegible]	2
90	1.51031	484	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3
9800	1.51516	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2
10	1.52003	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3
20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
40	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
60	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
70	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
80	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
90	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9900	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
40	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
60	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
70	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
80	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
90	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

D	J	Diff.	A	Diff.	T	Diff.	*u*	Diff.
10000	1.61491	510	4374.18	16.12	24.060	51	195.9	2
10	1.62003	512	4390.35	16.17	24.111	51	195.7	2
20	1.62516	513	4406.58	16.23	24.163	52	195.4	[illegible]
30	1.63030	514	4422.86	16.28	24.214	51	195.2	
40	1.63545	515	4439.19	16.33	24.265	51	194.9	
50	1.64062	517	4455.57	16.38	24.316	51	194.7	
60	1.64580	518	4472.00	16.43	24.368	52	194.4	
70	1.65099	519	4488.48	16.48	24.419	51	194.2	
80	1.65619	520	4505.02	16.54	24.471	52	194.0	
90	1.66141	522	4521.61	16.59	24.522	51	193.7	
10100	1.66664	523	4538.25	16.64	24.574	52	193.5	
10	1.67189	525	4554.94	16.69	24.626	52	193.2	
20	1.67715	526	4571.69	16.73	24.678	52	193.0	
30	1.68242	527	4588.48	16.79	24.730	52	192.7	
40	1.68770	528	4605.33	16.85	24.781	51	192.5	
50	1.69300	530	4622.24	16.91	24.833	52	192.3	
60	1.69831	531	4639.20	16.96	24.885	52	192.0	
70	1.70363	532	4656.21	17.01	24.937	52	191.8	
80	1.70896	533	4673.27	17.06	24.989	52	191.6	
90	1.71431	535	4690.38	17.11	25.041	52	191.3	
10200	1.71967	536	4707.55	17.18	25.094	53	191.1	[illegible]
10	1.72505	538	4724.78	17.23	25.146	52	190.9	[illegible]
20	1.73044	539	4742.05	17.27	25.198	52	190.6	
30	1.73585	541	4759.39	17.34	25.251	53	190.4	
40	1.74127	542	4776.77	17.38	25.303	52	190.2	
50	1.74670	543	4794.21	17.44	25.356	53	189.9	3
60	1.75214	544	4811.70	17.49	25.409	53	189.7	2
70	1.75760	546	4829.25	17.55	25.462	53	189.5	2
80	1.76307	547	4846.86	17.61	25.515	53	189.2	3
90	1.76855	548	4864.51	17.65	25.568	53	189.0	2
10300	1.77404	549	4882.23	17.72	25.621	53	188.8	2
10	1.77955	551	4900.00	17.77	25.675	54	188.5	3
20	1.78507	552	4917.82	17.82	25.728	53	188.3	2
30	1.79061	554	4935.70	17.88	25.781	53	188.1	2
40	1.79616	555	4953.63	17.93	25.834	53	187.8	3
50	1.80172	556	4971.62	17.99	25.888	54	187.5	2
60	1.80730	558	4989.67	18.05	25.941	53	187.4	2
70	1.81289	559	5007.77	18.10	25.994	53	187.1	3
80	1.81850	561	5025.92	18.15	26.047	53	186.9	2
90	1.82412	562	5044.14	18.22	26.100	53	186.7	2
10400	1.82976	564	5062.41	18.27	26.154	54	186.4	3
10	1.83541	565	5080.73	18.32	26.208	54	186.2	2
20	1.84107	566	5099.11	18.38	26.261	53	186.0	2
30	1.84674	567	5117.55	18.44	26.315	54	185.8	2
40	1.85243	569	5136.04	18.49	26.369	54	185.5	3
50	1.85814	571	5154.60	18.56	26.423	54	185.3	2
60	1.86386	572	5173.21	18.61	26.477	54	185.1	2
70	1.86959	573	5191.88	18.67	26.531	54	184.9	2.
80	1.87534	575	5210.60	18.72	26.585	54	184.6	3
90	1.88110	576	5229.39	18.79	26.639	54	184.4	2

D	J	Diff.	A	Diff.	T	Diff.	*u*	Diff.
500	1.88688	578	5248.23	18.84	26.693	54	184.2	2
10	1.89270	579	5267.12	18.89	26.747	54	184.0	2
20	1.89850	580	5286.08	18.96	26.802	55	183.7	3
30	1.90431	581	5305.09	19.01	26.856	54	183.5	2
40	1.91013	582	5324.17	19.08	26.911	55	183.3	2
50	1.91597	584	5343 30	19.13	26.966	55	183.1	2
60	1.92182	585	5362.49	19.19	27.020	54	182.8	3
70	1.92769	587	5381.73	19.24	27.075	55	182.6	2
80	1.93358	589	5401.04	19.31	27.130	55	182.4	2
90	1.93948	590	5420.40	19.36	27.185	55	182.2	2
600	1.94538	592	5439.83	19.43	27.240	55	182.0	2
10	1.95131	593	5459.31	19.48	27.295	55	181.8	2
20	1.95725	594	5478.85	19.54	27.350	55	181.5	3
30	1.96320	595	5498.46	19.61	27.406	56	181.3	2
40	1.96911	597	5518.12	19.66	27.461	55	181.1	2
50	1.97515	598	5537.84	19.72	27.516	55	180.9	2
60	1.98115	600	5557.62	19.78	27.571	55	180.7	2
70	1.98716	601	5577.46	19.84	27.626	55	180.5	2
80	1.99319	603	5597.37	19.91	27.681	55	180.2	3
90	1.99924	605	5617.33	19.96	27.737	56	180.0	2
700	2.00530	606	5637.35	20.02	27.792	55	179.8	2
10	2.01138	608	5657.43	20.08	27.848	56	179.6	2
20	2.01747	609	5677.58	20.15	27.904	56	179.4	2
30	2.02357	610	5697.78	20.20	27.960	56	179.1	3
40	2.02969	612	5718.05	20.27	28.016	56	178.9	2
50	2.03582	613	5738.38	20.33	28.072	56	178.7	2
60	2.04196	615	5758.77	20.39	28.128	56	178.5	2
70	1.04313	616	5779.22	20.45	28.184	56	178.3	2
80	2.05431	618	5799.73	20.51	28.240	56	178.0	3
[illegible]	2.06051	620	5820.30	20.57	28.296	56	177.8	2
0	2.06672	621	5840.94	20.64	28.352	56	177.6	2
10	2.07295	623	5861.64	20.70	28.408	56	177.4	2
20	2.07919	624	5882.40	20.76	28.465	57	177.2	2
30	2.08544	625	5903.22	20.82	28.521	56	177.0	2
40	2.09171	627	5924.11	20.89	28.578	57	176.7	3
50	2.09800	629	5745.05	20.94	28.634	56	176.5	2
60	2.10430	630	5966.07	21.02	28.691	57	176.3	2
70	2.11062	632	5987.14	21.07	28.748	57	176.1	2
80	2.11695	633	6008.28	21.14	28.805	57	175.8	3
90	2.12330	635	6029.48	21.24	28.862	57	175.6	2
900	2.12967	637	6050.74	21.26	28.919	57	175.4	2
10	2.13605	638	6072.07	21.33	29.077	58	175.2	2
20	2.14245	640	6093.47	21.40	29.034	57	175.0	2
30	2.14887	642	6114.92	21.45	29.091	57	174.8	2
40	2.15530	643	6136.44	21.52	29.148	57	174.6	2
50	2.16174	644	6158.03	21.59	29.206	58	174.4	2
60	2.16820	646	6179.68	21.65	29.263	57	174.1	3
70	2.17467	647	6201.39	21.71	29.320	57	173.9	2
80	2.18115	648	6223.17	21.78	29.377	57	173.7	2
90	2.18765	650	6245.02	21.85	29.434	57	173.5	2

D	J	Diff.	A	Diff.	T	Diff.	*u*	Diff.
11000	2.19416	651	6266.92	21.90	29.492	58	173.3	2
10	2.20069	653	6288.90	21.98	29.549	57	173.0	
20	2.20724	655	6310·94	22.04	29.607	58	172.8	
30	2.21381	657	6333.04	22.10	29.665	58	172.6	
40	2.22039	668	6355.21	22.17	29.723	58	172.4	
50	2.22699	660	6377.45	22.24	29.781	58	172.2	
60	2.23361	662	6399.75	22.30	29.839	58	172.0	
70	2.24025	664	6422.12	22.37	29.897	58	171.8	
80	2.24691	666	6444.56	22.44	29.955	58	171.6	
90	2.25359	668	6467.06	22.50	30.014	59	171.4	
11100	2.26028	669	6489.63	22.57	30.072	58	171.2	
10	2.26698	670	6512.27	22.64	30.130	58	171.0	
20	2.27370	672	6534.97	22.70	30.189	59	170.8	
30	2.28043	673	6557.74	22.77	30.247	58	170.6	
40	2.28718	675	6580.58	22.84	30.306	59	170.4	
50	2.29394	676	6603.49	22.91	30.365	59	170.2	
60	2.30072	678	6626.46	22.97	30.424	59	170.0	
70	2.30752	680	6649.50	23.04	30.483	59	169.8	
80	2.31433	681	6672.61	23.11	30.542	59	169.6	
90	2.32116	683	6695.79	23.18	30.601	59	169.4	
11200	2.32800	684	6719.03	23.24	30.660	59	169.1	
10	2.33486	686	6742.35	23.32	30.720	60	168.9	
20	2.34174	688	6765.73	23.38	30.779	59	168.7	
30	2.34864	690	6789.18	23.45	30.838	59	168.5	
40	2.35555	691	6812.70	23.52	30.898	60	168.3	
50	2.36248	693	6836.29	23.59	30.957	59	168.1	
60	2.36943	695	6859.95	23.66	31.017	60	167.9	
70	2.37640	697	6883.68	23.73	31.076	59	167.7	
80	2.38339	699	6907.48	23.80	31.136	60	167.5	
90	2.39039	700	6931.35	23.87	31.195	59	167.3	
11300	2.39741	702	6955.29	23.94	31.255	60	167.0	
10	2.40445	704	6979.30	24.01	31.315	60	166.8	
20	2.41151	706	7003.38	24.08	31.375	60	166.6	
30	2.41858	707	7027.53	24.15	31.435	60	166.4	
40	2.42567	709	7051.75	24.22	31.495	60	166.2	
50	2.43278	711	7076.04	24.29	31.555	60	166.0	
60	2.43971	713	7100.40	24.36	31.616	61	165.8	
70	2.45705	714	7124.84	24.44	31.676	60	165.6	
80	2.45421	716	7149.35	24.51	31.736	60	165.4	
90	2.46139	718	7173.92	24.57	31.796	60	165.2	
11400	2.46858	719	7198.57	24.65	31.857	61	165.0	
10	2.47579	721	7223.30	24.73	31.917	60	164.8	
20	2.48302	723	7248.09	24.79	31.978	61	164.6	
30	2.49027	725	7272.96	24.87	32.039	61	164.4	
40	2.49753	726	7297.90	24.94	32.100	61	164.2	
50	2.50481	728	7322.91	25.01	32.161	61	164.0	
60	2.51211	730	7347.99	25.08	32.222	61	163.8	
70	2.51943	732	7373.15	25.16	32.283	61	163.6	
80	2.52677	734	7398.38	25.23	32.344	61	163.4	
90	2.53413	736	7423.68	25.30	32.405	61	163.2	

J	Diff.	A	Diff.	T	Diff.	*u*	Diff.
2.54150	737	7449.06	25.38	32.467	62	163.0	2
2.54889	739	7474.51	25.45	32.528	61	162.8	2
2.55629	740	7500.04	25.53	32.589	61	162.6	2
2.56371	742	7525.64	25.60	32.651	62	162.4	2
2.57115	744	7551.32	25.68	32.712	61	162.2	2
2.57861	746	7577.06	25.74	32.774	62	162.0	2
2.58609	748	7602.89	25.83	32.835	61	161.8	2
2.59359	750	7628.79	25.90	32.897	62	161.6	2
2.60112	753	7654.76	25.96	32.959	62	161.4	2
2.60866	754	7680.81	26.05	33.021	62	161.2	2
2.61622	756	7706.93	26.12	33.084	63	161.0	2
2.62379	757	7733.13	26.20	33.146	62	160.8	2
2.63138	759	7759.41	26.28	33.208	62	160.6	2
2.63899	761	7785.76	26.35	33.271	63	160.5	1
2.64662	763	7812.19	26.43	33.333	62	160.3	2
2.65426	764	7838.69	26.50	33.396	63	160.1	2
2.66191	765	7865.27	26.58	33.458	62	159.9	2
2.66959	768	7891.93	26.66	33.521	63	159.7	2
2.67729	770	7918.67	26.74	33.583	62	159.5	2
2.68501	772	7945.48	26.81	33.646	63	159.3	2
2.60275	774	7972.37	26.89	33.709	63	159.1	2
2.70051	776	7999.33	26.96	33.772	63	158.9	2
2.70820	778	8026.38	27.05	33.836	64	158.7	2
2.71609	780	8053.50	27.12	33.899	63	158.5	2
2.72391	782	8080.70	27.20	33.962	63	158.3	2
2.73174	783	8107.98	27.28	34.026	64	158.1	2
2.73959	785	8135.33	27.35	34.089	63	157.9	1
2.74746	787	8162.77	27.44	34.152	63	157.8	2
2.75535	789	8190.28	27.51	34.216	64	157.6	2
2.76326	791	8217.88	27.60	34.279	63	157.4	
2.77119	793	8245.55	27.67	34.342	63	157.2	2
2.77914	795	8273.30	27.75	34.405	63	157.0	2
2.78711	797	8301.13	27.83	34.469	64	156.8	2
2.79510	799	8329.04	27.91	34.532	63	156.6	2
2.80311	801	8357.03	37.99	34.596	64	156.4	2
2.81114	803	8385.10	28.07	34.660	64	156.2	2
2.81919	805	8413.26	28.16	34.724	64	156.0	2
2.82726	807	8441.49	28.23	34.789	65	155.8	2
2.83535	809	8469.80	28.31	34.853	64	155.6	2
2.84345	810	8498.19	28.39	34.917	64	155.4	2
2.85157	812	8526.67	28.48	34.982	65	155.2	2
2.85972	815	8555.23	28.56	35.046	64	155.1	1
2.86789	817	8583.86	28.63	35.111	65	154.9	2
2.87608	819	8612.58	28.72	35.175	64	154.7	2
2.88429	821	8641.39	28.81	35.240	65	154.5	2
2.89252	823	8670.27	28.88	35.305	65	154.3	2
2.90077	825	8699.24	28.97	35.370	65	154.1	2
2.90904	827	8728.29	29.05	35.435	65	153.9	2
2.91733	829	8757.42	29.13	35.500	65	153.7	2
2.92564	831	8786.63	29.21	35.565	65	153.5	2

D	J	Diff.	A	Diff.	T	Diff.	*u*	Diff.
12000	2.93396	832	8815.93	29.30	35.630	65	153.3	2
10	2.94231	835	8845.31	29.38	35.696	66	153.1	2
20	2.95068	837	8874.78	29.47	35.761	65	153.0	1
30	2.95907	839	8904.32	29.54	35.826	65	152.8	2
40	2.96748	841	8933.96	29.64	35.892	66	152.6	2
50	2.97591	843	8963.67	29.71	35.957	65	152.4	2
60	2.98436	845	8993.48	29.81	36.023	66	152.2	2
70	2.99284	848	9023.36	29.88	36.088	65	152.0	2
80	3.00134	850	9053.33	29.97	36.154	66	151.9	1
90	3.00986	852	9083.39	30.06	36.220	66	151.7	2
12100	3.01840	854	9113.53	30.14	36.286	66	151.5	[illegible]
10	3.02696	856	9143.76	30.23	93.352	66	151.3	[illegible]
20	3.03554	858	9174.07	30.31	36.419	67	151.1	[illegible]
30	3.04414	860	9204.47	30.40	36.485	66	151.0	[illegible]
40	3.05276	862	9234.95	30.48	36.551	66	150.8	[illegible]
50	3.06140	864	9265.52	30.57	36.618	67	150.6	[illegible]
60	3.07006	866	9296.18	30.66	36.684	66	150.4	[illegible]
70	3.07874	868	9326.92	30.74	36.750	66	150.3	[illegible]
80	3.08743	869	9357.76	30.84	36.817	67	150.1	[illegible]
90	3.09614	871	9388.67	30.91	36.883	66	149.9	[illegible]
12200	3.10487	873	9419.68	31.01	36.950	67	149.7	2
10	3.11363	876	9450.77	31.09	37.017	67	149.5	2
20	3.12241	878	9481.95	31.18	37.084	67	149.4	1
30	3.13121	880	9519.22	31.27	37.151	67	149.2	2
40	3 14003	882	9544.57	31.35	37.218	67	149.0	2
50	3.14888	885	9576.02	31.45	37.286	68	148.8	2
60	3.15775	887	9607.55	31.53	37.353	67	148.7	1
70	3.16664	889	9639.17	31.64	37.420	67	148.5	2
80	3.17555	891	9670.89	31.72	37.487	67	148.3	2
90	3 18448	893	9702.69	31.80	37.555	68	148.1	2
12300	3.19344	896	9734.58	31.89	37.622	67	147.9	2
10	3.20242	898	9766.55	31.97	37.690	68	147.8	1
20	3.21142	900	9798.62	32.07	37.758	68	147.6	2
30	3.22044	902	9830.78	32.16	37.825	67	147.4	2
40	3.22948	904	9863.03	32.25	37.893	68	147.2	2
50	3.23955	907	9895.37	32.34	37.961	68	147.0	2
60	3.24764	909	9927.80	32.43	38.029	68	146.9	1
70	3.25675	911	9960.33	32.53	38.097	68	146.7	2
80	3.26588	913	9992 94	32.61	38.165	68	146.5	2
90	3.27503	915	10025.64	32.70	38.234	68	146.3	2
12400	3.28420	917	10058.44	32.80	38.302	68	146.1	2
10	3.29340	920	10091.33	32.89	38.370	68	146.0	1
20	3.30262	922	10124.31	32.98	38.439	69	145.8	2
30	3.31186	924	10157.38	33.07	38.508	69	145.6	2
40	3.32112	926	10190.54	33.16	38.576	68	145.4	2
50	3.33041	929	10223.80	33.26	38.645	69	145.2	2
60	3.33972	931	10257.15	33.35	38.714	69	145.1	1
70	3.34906	934	10290.60	33.45	38.783	69	144.9	2
80	3.35842	936	10324.13	33.53	38.852	69	144.7	2
90	3.36780	938	10357.77	33.64	38.921	69	144.5	2

J	Diff.	A	Diff.	T	Diff.	u	Diff.
3.37721	941	10391.49	33.72	38.991	70	144.3	2
3.38664	943	10425.31	33.82	39.060	69	144.1	2
3.39609	945	10459.22	33 91	39.129	69	144.0	1
3.40556	947	10493.23	34.01	39.199	70	143.8	2
3.51505	949	10527.33	34.10	39.268	69	143.6	2
3.42457	952	10561.53	34.20	39.338	70	143.5	1
3.43410	953	10595.83	34.30	39.407	69	143.3	2
3.44366	956	10630.21	34.38	39.477	70	143.1	2
3.45324	958	10664.20	34.49	39.547	70	143.0	1
3.46284	960	10699.28	34.58	39.617	70	142.8	2
3.47247	963	10733.96	34.68	39.687	70	142.6	2
3.48212	965	10768.73	34.77	39.758	71	142 5	1
3.49179	967	10803.60	34.87	39.828	70	142.3	2
3.50148	969	10838.56	34.96	39.898	70	142.1	2
3.51119	972	10873.63	35.07	39.968	70	142.0	1
3.52093	974	10908.79	35.16	40.039	71	141.8	2
3.53070	977	10944.05	35.26	40.109	70	141.6	2
3.54049	979	10979.40	35.35	40.180	71	141.5	1
3.55030	981	11014.86	35.46	40.250	70	141.3	2
3.56014	984	11050.41	35.55	40.321	71	141.1	2
3.57000	986	11086.06	35.65	40.392	71	141.0	1
3.57989	989	11121.81	35.75	40.463	71	140.8	2
3.58980	991	11157.66	35.85	40.534	71	140.6	2
3.59973	993	11193.60	35.94	40.605	71	140.5	1
3.60969	996	11229.65	36.05	40.677	72	140.3	2
3.61967	998	11265.80	36.15	40.748	71	140.1	2
3.62967	1000	11302.04	36.24	40.819	71	140.0	1
3.63969	1002	11338.39	36.35	40.891	72	139.8	2
3.64973	1004	11374.84	36.45	40.962	71	139.6	2
3.65980	1007	11411.39	36.55	41.034	72	139.5	1
3.66989	1009	11448.03	36.64	41.106	72	139.3	2
3.68001	1012	11484.78	36.75	41.178	72	139.1	2
3.69015	1014	11521.64	36.86	41.250	72	139.0	1
3.70032	1017	11558.59	36.95	41.322	72	138.8	2
3.71051	1019	11595.64	37.05	41.395	73	138.6	2
3.72073	1022	11632.80	37.16	41.467	72	138.4	2
3.73098	1025	11670.06	37.26	41.539	72	138.3	1
3.74126	1028	11707.42	37.36	41.611	72	138.1	2
3.75156	1030	11744.88	37.46	41.684	73	137.9	2
3.76189	1033	11782.45	37.57	41.756	72	137.7	2
3.77225	1036	11820.12	37.67	41.829	73	137.6	1
3.87263	1038	11857.89	37.77	41.901	73	137.4	2
3.79303	1040	11895.77	37.88	41.974	73	137.2	2
3.80346	1043	11933.76	37.99	42.047	73	137.1	1
3.81391	1045	11971.84	38.08	42.120	73	136.9	2
3.82439	1048	12010.03	38.19	42.193	73	136.7	2
3.83489	1050	12048.33	38.30	42.267	74	136.5	2
3.84542	1053	12086.73	38.40	42.340	73	136.4	1
3.85597	1055	12125.24	38.51	42.413	73	136.2	2
3.86655	1058	12163.85	38.61	42.486	73	136.0	2

D	J	Diff.	A	Diff.	T	Diff.	*u*	Diff.
13000	3.8772	1061	12202.6	38.72	42.560	74	135.9	1
10	3.8878	106	12241.4	38.8	42.634	74	135.7	2
20	3.8985	107	12280.3	38.9	42.708	74	135.5	2
30	3.9092	107	12319.4	39.1	42.782	74	135.4	1
40	3.9200	108	12358.5	39.1	42.856	74	135.2	2
50	3.9307	107	12397.8	39.3	42.930	74	135.1	1
60	3.9415	108	12439.7	39.3	43.004	74	134.9	2
70	3.9522	107	12476.6	39.5	43.077	73	134.7	2
80	3.9630	108	12516.2	39.6	43.151	74	134.5	2
90	3.9738	108	12555.9	39.7	43.225	74	134.4	1
13100	3.9846	108	12595.6	39.7	43.300	75	134.2	2
10	3.9955	109	12635.5	39.9	43.374	74	134.0	2
20	4.0064	109	12675.6	40.1	43.449	75	133.9	1
30	4.0174	110	12715.7	40.1	43.524	75	133.7	2
40	4.0283	109	12755.9	40.2	43.599	75	133.6	1
50	4.0393	110	12796.2	40.3	43.673	74	133.4	2
60	4.0503	110	12836.7	40.3	43.748	75	133.3	1
70	4.0614	111	12877.2	40.5	43.823	75	133.1	2
80	4.0725	111	12917.9	40.7	43.898	75	133.0	1
90	4.0836	111	12958.7	40.8	43.973	75	132.9	1
13200	4.0948	112	12999.6	40.9	44.049	76	132.7	2
10	4.1060	112	13040.6	41.0	44.124	75	132.5	2
20	4.1172	112	13081.7	41.1	44.200	76	132.4	1
30	4.1285	113	13122.9	41.2	44.275	75	132.2	2
40	4.1397	112	13164.3	41.4	44.351	76	132.0	2
50	4.1510	113	13205.7	41.4	44.427	76	131.9	1
60	4.1622	112	13247.3	41.6	44.503	76	131.7	2
70	4.1735	113	13289.0	41.7	44.579	76	131.6	1
80	4.1848	113	13330.8	41.8	44.655	76	131.4	2
90	4.1962	114	13372.7	41.9	44.731	76	131.3	1
13300	4.2076	114	13414.7	42.0	44.807	76	131.1	2
10	4.2190	114	13456.8	42.1	44.884	77	131.0	1
20	4.2305	115	13499.1	42.3	44.960	76	130.8	2
30	4.2419	114	13541.4	42.3	45.036	76	130.6	2
40	4.2534	115	13583.9	42.5	45.113	77	130.4	2
50	4.2649	115	13626.5	42.6	45.190	77	130.3	1
60	4.2765	116	13669.2	42.7	45.267	77	130.1	2
70	4.2881	116	13712.0	42.8	45.344	77	129.9	2
80	4.2998	117	13755.0	43.0	45.421	77	129.8	1
90	4.3114	116	13798.0	43.0	45.498	77	129.6	2
13400	4.3231	117	13841.2	43.2	45.575	77	129.4	2
10	4.3348	117	13884.5	43.3	45.653	78	129.3	1
20	4.3465	117	13927.9	43.4	45.730	78	129.1	2
30	4.3583	118	13971.4	43.5	45.807	77	129.0	1
40	4.3701	118	14015.1	43.7	45.885	78	128.8	2
50	4.3819	118	14058.8	43.7	45.962	77	128.6	2
60	4.3938	119	14102.7	43.9	46.040	78	128.5	1
70	4 4057	119	14146.7	44.0	46.118	78	128.3	2
80	4.4176	119	14190.8	44.1	46.196	78	128.2	1
90	4.4296	120	14235.1	44.3	46.274	78	128.0	2

D	J	Diff.	A	Diff.	T	Diff	*u*	Diff.
13500	4.4416	120	14279.4	44.3	46.352	78	127.9	1
10	4.4536	120	14323.9	44.5	46.431	79	127.7	2
20	4.4657	121	14368.5	44.6	46.509	78	127.6	1
30	4.4778	121	14413.2	44.7	46.587	78	127.4	2
40	4.4899	121	14458.0	44.8	46.665	78	127.3	1
50	4.5020	121	14503.0	45.0	46.744	79	127.1	2
60	4.5142	122	14548.1	45.1	46.822	78	127.0	1
70	4.5263	121	14593.3	45.2	46.901	79	126.8	2
80	4.5385	122	14638.6	45.3	46.980	79	126.6	2
90	4.5507	122	14684.0	45.4	47.059	79	126.5	1
13600	4.5620	122	14729.6	45.6	47.138	79	126.3	2
10	4.5752	123	14775.3	45.7	47.218	80	126.2	1
20	4.5875	123	14821.1	45.8	47.297	79	126.0	2
30	4.5998	123	14867.1	46.0	47.376	79	125.9	1
40	4.6122	124	14913.1	46.0	47.456	80	125.7	2
50	4.6246	124	14959.3	46.2	47.535	79	125.6	1
60	4.6370	124	15005.6	46.3	47.615	80	125.4	2
70	4.6495	125	15052.0	46.4	47.695	80	125.3	1
80	4.6620	125	15098.6	46.6	47.775	80	125.2	1
90	4.6746	126	15145.3	46.7	47.855	80	125.0	2
13700	4.6872	126	15192.1	46.8	47.935	80	124.9	1
10	4.6998	126	15239.0	46.9	48.016	81	124.7	2
20	4.7125	127	15286.1	47.1	48.096	80	124.6	1
30	4.7252	127	15333.3	47.2	48.176	80	124.4	2
40	4.7379	127	15380.6	47.3	48.257	81	124.3	1
50	4.7506	127	15428.0	47.4	48.337	80	124.1	2
60	4.7634	128	15475.6	47.6	48.418	81	124.0	1
70	4.7761	127	15523.3	47.7	48.498	80	123.8	2
80	4.7889	128	15571.1	47.8	48.579	81	123.7	1
90	4.8017	128	15619.1	48.0	48.659	80	123.5	2
13800	4.8145	128	15667.2	48.1	48.740	81	123.4	1
10	4.8274	129	15715.4	48.2	48.821	81	123.2	2
20	4.8403	129	15763.7	48.3	48.902	81	123.1	1
30	4.8533	130	15812.2	48.5	48.983	81	122.9	2
40	4.8663	130	15860.8	48.6	49.065	82	122.8	1
50	4.8794	131	15909.5	48.7	49.146	81	122.6	2
60	4.8924	130	15958.4	48.9	49.228	82	122.5	1
70	4.9055	131	16007.4	49.0	49.310	82	122.3	2
80	4.9186	131	16056.5	49.1	49.392	82	122.2	1
90	4.9318	132	16105.7	49.2	49.474	82	122.0	2
13900	4.9450	132	16155.1	49.4	49.556	82	121.9	1
10	4.9582	132	16204.6	49.5	49.639	83	121.7	2
20	4.9815	133	16254.3	49.7	49.721	82	121.6	1
30	4.9848	133	16304.1	49.8	49.803	82	121.4	2
40	4.9982	134	16354.0	49.9	49.886	83	121.3	1
50	5.0115	133	16404.0	50.0	49.968	82	121.1	2
60	5.0249	134	16454.2	50.2	50.051	83	121.0	1
70	5.0383	134	16504.5	50.3	50.133	82	120.8	2
80	5.0517	134	16555.0	50.5	50.216	63	120.7	1
90	5.0652	135	16605.6	50.6	50.298	82	120.5	2

D	J	Diff.	A	Diff.	T	Diff.	*u*	Diff.
14000	5.0787	135	16656.3	50.7	50.381	83	120.4	1
10	5.0922	135	16707.1	50.8	50.464	83	120.2	2
20	5.1058	136	16758.1	51.0	50.547	83	120.1	1
30	5.1194	136	16809.2	51.1	50.631	84	120.0	1
40	5.1331	137	16860.5	51.3	50.714	83	119.8	2
50	5.1468	137	16911.9	51.4	50.798	84	119.7	1
60	5.1605	137	16963.4	51.5	50.881	83	119.5	2
70	5.1743	138	17015.1	51.7	50.965	84	119.4	1
80	5.1880	137	17066.9	51.8	51.049	84	119.2	2
90	5.2018	138	17118.9	52.0	51.133	84	119.1	1
14100	5.2156	138	17171.0	52.1	51.217	84	119.0	1
10	5.2295	139	17223.2	52.2	51.302	85	118.8	2
20	5.2434	139	17275.6	52.4	51.386	84	118.7	1
30	5.2573	139	17328.1	52.5	51.470	84	118.5	2
40	5.2713	140	17380.7	52.6	51.555	85	118.4	1
50	5.2853	140	17433.5	52.8	51.639	84	118.2	2
60	5.2993	140	17486.4	52.9	51.723	84	118.1	1
70	5.3134	141	17539.5	53.1	51.808	85	117.9	2
80	5.3275	141	17592.7	53.2	51.893	85	117.8	1
90	5.3417	142	17646.0	53.3	51.978	85	117.7	1
14200	5.3559	142	17699.5	53.5	52.063	85	117.5	2
10	5.3701	142	17753.1	53.6	52.149	86	117.4	1
20	5.3844	143	17806.9	53.8	52.235	85	117.2	2
30	5.3986	142	17860.8	53.9	52.319	85	117.1	1
40	5.4129	143	17914.9	54.1	52.405	86	117.0	1
50	5.4273	144	17969.1	54.2	52.490	85	116.8	2
60	5.4417	144	18023.4	54.3	52.576	86	116.7	1
70	5.4562	145	18077.9	54.5	52.651	85	116.5	2
80	5.4706	144	18132.5	54.6	52.747	86	116.4	1
90	5.4851	145	18187.3	54.8	52.833	86	116.2	2
14300	5.4996	145	18242.2	54.9	52.919	86	116.1	1
10	5.5142	146	18297.2	55.1	53.006	87	115.9	2
20	5.5288	146	18352.5	55.2	53.092	86	115.8	1
30	5.5435	147	18407.9	55.4	53.178	86	115.7	1
40	5.5581	146	18463.4	55.5	53.265	87	115.5	2
50	5.5728	147	18519.1	55.7	53.351	86	115.4	1
60	5.5875	147	18574.9	55.8	53.438	87	115.2	2
70	5.6023	148	18630.8	55.9	53.524	86	115.1	1
80	5.6171	148	18686.9	56.1	53.611	87	115.0	1
90	5.6320	148	18743.1	56.2	53.698	87	114.8	2
14400	5.6469	149	18799.5	56.4	53.785	87	114.7	1
10	5.6618	149	18856.1	56.6	53.873	88	114.5	2
20	5.6768	150	18912.8	56.7	53.960	87	114.4	1
30	5.6918	150	18969.6	56.8	54.048	88	114.3	1
40	5.7069	151	19026.6	57.0	54.136	88	114.1	2
50	5.7220	151	19083.8	57.2	54.224	88	114.0	1
60	5.7371	151	19141.1	57.3	54.311	87	113.9	1
70	5.7523	152	19198.5	57.4	54.399	88	113.7	2
80	5.7674	151	19256.1	57.6	54.487	88	113.6	1
90	5.7826	152	19313.9	57.8	54.575	88	113.5	1

D	J	Diff.	A	Diff.	T	Diff.	*u*	Diff.
4500	5.7978	152	19371.8	57.9	54.663	88	113.3	2
10	5.8131	153	19429.8	58.0	54.752	89	113.2	1
20	5.8284	153	19488.0	58.2	54.840	88	113.1	1
30	5.8438	154	19546.4	58.4	54.929	89	112.9	2
40	5.8592	154	19604.9	58.5	55.017	88	112.8	1
50	5.8747	155	19663.6	58.7	55.106	89	112.6	2
60	5.8901	154	19722.4	58.8	55.195	89	112.5	1
70	5.9056	155	19781.4	59.0	55.284	89	112.4	1
80	5.9212	156	19840.5	59.1	55.373	89	112.2	2
90	5.9368	156	19899.8	59.3	55.461	88	112.1	1
4600	5.9524	156	19959.2	59.4	55.550	89	112.0	1
10	5.9681	157	20018.8	59.6	55.639	89	111.8	2
20	5.9838	157	20078.6	59.8	55.729	90	111.7	1
30	5.9996	158	20138.5	59.9	55.818	89	111.5	2
40	6.0153	157	20198.6	60.1	55.908	90	111.4	1
50	6.0311	158	20258.8	60.2	55.998	90	111.3	1
60	6.0469	158	20319.2	60.4	56.088	90	111.1	2
70	6.0628	159	20379.8	60.6	56.178	90	111.0	1
80	6.0787	159	20440.5	60.7	56.268	90	110.9	1
90	6.0947	160	20501.3	60.8	56.358	90	110.7	2
0	6.1106	159	20562.4	61.1	56.449	91	110.6	1
	6.1266	160	20623.5	61.1	56.539	90	110.5	1
20	6.1427	161	20684.9	61.4	56.629	90	110.4	1
30	6.1588	161	20746.4	61.5	56.720	91	110.2	2
40	6.1750	162	20808.1	61.7	56.810	90	110.1	1
50	6.1912	162	20869.9	61.8	56.901	91	110.0	1
60	6.2074	162	20931.9	62.0	56.992	91	109.8	2
70	6.2231	163	20994.0	62.1	57.083	91	109.7	1
80	6.2400	163	21056.4	62.4	57.174	91	109.6	1
90	6.2563	163	21118.8	62.4	57.266	92	109.4	2
14800	6.2727	164	21181.5	62.7	57.358	92	109.3	1
10	6.2891	164	21244.3	62.8	57.449	91	109.2	1
20	6.3055	164	21307.3	63.0	57.541	92	109.1	1
30	6.3220	165	21370.4	63.1	57.633	92	108.9	2
40	6.3385	165	21433.7	63.3	57.723	92	108.8	1
50	6.3551	166	21497.2	63.5	57.816	91	108.7	1
60	6.3718	167	21560.8	63.6	57.908	92	108.5	2
70	6.3885	167	21624.6	63.8	58.000	92	108.4	1
80	6.4053	168	21688.6	64.0	58.091	92	108.3	1
90	6.4420	167	21752.7	64.1	58.184	92	108.1	2
4900	6.4388	168	21817.0	64.3	58.277	93	108.0	1
10	6.4557	169	21881.5	64.5	58.369	92	107.9	1
20	6.4726	169	21946.1	64.6	58.461	92	107.7	2
30	6.4896	170	22011.0	64.9	58.554	93	107.6	1
40	6.5065	169	22075.9	64.9	58.646	92	107.5	1
50	6.5235	170	22141.1	65.2	58.739	93	107.4	1
60	6.5405	170	22206.4	65.3	58.832	93	107.2	2
70	6.5576	171	22271.9	65.5	58.926	94	107.1	1
80	6.5747	171	22337.6	65.7	59.020	94	107.0	1
90	6.5919	172	22403.4	65.8	59.114	94	106.8	2

D	J	Diff.	A	Diff.	T	Diff.	*u*	Diff.
15000	6.6091	172	22469.4	66.0	59.209	95	106.7	1
10	6.6264	173	22535.6	66.2	59.303	94	106.5	2
20	6.6437	173	22601.9	66.3	59.397	94	106.4	1
30	6.6610	173	22668.4	66.5	59.492	95	106.3	1
40	6.6784	174	22735.1	66.7	59.586	94	106.1	2
50	6.6958	174	22802.0	66.9	59.680	94	106.0	1
60	6.7133	175	22869.1	67.1	59.774	94	105.9	1
70	6.7308	175	22936.3	67.2	59.868	94	105.7	2
80	6.7484	176	23003.7	67.4	59.963	95	105.6	1
90	6.7660	176	23071.3	67.6	60.057	94	105.5	1
15100	6.7837	177	23139.0	67.7	60.152	95	105.3	2
10	6.8014	177	23206.9	67.9	60.247	95	105.2	1
20	6.8192	178	23275.0	68.1	60.342	95	105.1	
30	6.8370	178	23343.3	68.3	60.437	95	105.0	
40	6.8548	178	23411.8	68.5	60.533	96	104.8	
50	6.8727	179	23480.4	68.6	60.628	95	104.7	
60	6.8906	179	23549.2	68.8	60.724	96	104.6	
70	6.9085	179	23618.2	69.0	60.819	95	104.5	
80	6.9265	180	23687.4	69.2	60.915	96	104.3	
90	6.9445	180	23756.7	69.3	61.011	96	104.2	
15200	6.9626	181	23826.3	69.6	61.107	96	104.1	
10	6.9807	181	23895.0	69.7	61.203	96	104.0	
20	6.9989	182	23965.9	69.9	61.299	96	103.8	
30	7.0171	182	24036.0	70.1	61.395	96	103.7	
40	7.0353	182	24106.2	70.2	61.492	97	103.6	
50	7.0536	183	24176.7	70.5	61.589	97	103.5	
60	7.0719	183	24247.3	70.6	61.685	96	103.3	
70	7.0903	184	24318.1	70.8	61.782	97	103.2	
80	7.1087	184	24389.1	71.0	61.879	97	103.1	
90	7.1272	185	24460.3	71.2	61.976	97	103.0	
15300	7.1457	185	24531.7	71.4	62.073	97	102.8	
10	7.1643	186	24603.2	71.5	62.171	98	102.7	
20	7.1829	186	24674.9	71.7	62.269	98	102.6	
30	7.2016	187	24746.9	72.0	62.366	97	102.5	
40	7.2203	187	24819.0	72.1	62.464	98	102.4	
50	7.2391	188	24891.3	72.3	62.562	98	102.2	
60	7.2579	188	24963.8	72.5	62.660	98	102.1	
70	7.2767	188	25036.4	72.6	62.757	97	102.0	
80	7.2956	189	25109.3	72.9	62.855	98	101.9	
90	7.3145	189	25182.3	73.0	62.953	98	101.8	
15400	7.3335	190	25255.6	73.3	63.052	99	101.6	2
10	7.3525	190	25329.0	73.4	63.151	99	101.5	
20	7.3715	190	25402.6	73.6	63.250	99	101.4	1
30	7.3906	191	25476.4	73.8	63.349	99	101.3	1
40	7.4098	192	25550.4	74.0	63.448	99	101.2	1
50	7.4290	192	25624.6	74.2	63.547	99	101.0	2
60	7.4483	193	25699.0	74.4	63.647	100	100.9	1
70	7.4676	193	25773.6	74.6	63.746	99	100.8	1
80	7.4869	193	25848.4	74.8	63.845	99	100.7	1
90	7.5063	194	25923.3	74.9	63.944	99	100.6	1

D	J	Diff.	A	Diff.	T	Diff	*u*	Diff.
15500	7.5227	194	25998.5	75.2	64.044	100	100.4	2
10	7.5452	195	26073.9	75.4	64.144	100	100.3	1
20	7.5647	195	26149.4	75.5	64.244	100	100.2	1
30	7.5843	196	26225.2	75.8	64.344	100	100.1	1
40	7.6039	196	26301.1	75.9	64.444	100	99.9	2
50	7.6236	197	26377.2	76.1	64.544	100	99.8	1
60	7.6433	197	26453.6	76.4	64.645	101	99.7	1
70	7.6631	198	26530.1	76.5	64.745	100	99.6	1
80	7.6829	198	26606.8	76.7	64.845	100	99.5	1
90	7.7028	199	26683.8	77.0	64.945	100	99.3	2
15600	7.7227	199	26760.9	77.1	65.046	101	99.2	1
10	7.7427	200	26838.2	77.3	65.147	101	99.1	1
20	7.7627	200	26915.7	77.5	65.248	101	99.0	1
30	7.7828	201	26993.5	77.8	65.349	101	98.9	1
40	7.8029	201	27071.4	77.9	65.451	102	98.7	2
50	7.8230	201	27149.5	78.1	65.552	101	98.6	1
60	7.8432	202	27227.9	78.4	65.654	102	98.5	1
70	7.8634	202	27306.4	78.5	65.755	101	98.4	1
80	7.8837	203	27385.1	78.7	65.856	101	98.3	1
90	7.9040	203	27464.1	79.0	65.958	102	98.2	1
15700	7.9244	204	27543.2	79.1	66.060	102	98.1	1
10	7.9448	204	27622.5	79.3	66.162	102	97.9	2
20	7.9653	205	27702.1	79.6	66.264	102	97.8	1
30	7.9858	205	27781.9	79.8	66.367	103	97.7	1
40	8.0064	206	27861.8	79.9	66.469	102	97.6	1
50	8.0270	206	27942.0	80.2	66.572	103	97.5	1
60	8.0477	207	28022.4	80.4	66.674	102	97.4	1
70	8.0684	207	28102.9	80.5	66.777	103	97.2	2
80	8.0891	207	28183.7	80.8	66.879	102	97.1	1
90	8.1099	208	28264.7	81.0	66.982	103	97.0	1
15800	8.1307	208	28345.9	81.2	67.085	103	96.9	1

PROFESSIONAL NOTES.

TACTICS.

History vs. Tactics.

Major E. S. May, R.A., is quite in accord with Dr. Miller Maguire as to the great advantage to be derived from the study of military history as a means of training for war. Major May regrets, as many others do, that nowadays we have so much "tactics" and so little military history in the course of study prescribed for regimental officers. The gallant gunner would have a cavalry officer familiar with the deeds of Seydlitz and Kellerman, Lasalle and Von Bredow, remember Rossbach, Zorndorf, Marengo, the pursuit after Jena and the surprise of Vionville, and eager with an ambition to emulate such deeds as those perpetuated in the accounts of these actions. Every artillery officer he would wish to see *au courant* with the story of Vittoria and Wagram, Hesse's and Gnügge's batteries at Gravelotte, of the "battery of the dead" at Königgrätz. Similarly all infantry officers should be persuaded of the invincibility of their arm; not because of the powers of modern rifles, but because infantry fought at Quatre Bras, at Inkerman, and at the Shipka Pass. Major May deplores the fact that "text books are now full of data as to the exact number of inches bullets will penetrate into various materials," and the actual time it will take to execute certain marches under given conditions. There is no doubt reason for the complaints of Dr. Maguire and Major May. The effect of much of our present examining has been to sicken men of service details and cause them to regard all military literature as more or less "a bore." In course of time we may hit upon the happy medium course, which all must be anxious to secure, for testing the capacity of our would-be Wellingtons. Meanwhile it should always be remembered, as Major May reminds us, that the chances on active service do not come to seniors only—that "Bonaparte at Rivoli and Wellington at Assaye were younger than many of our subalterns at the present time."

It is the fashion to suppose that the officers of the Army read very little and knew very little of the science of war at the commencement of the century. But Dr. Maguire and Major May dispute this; they both have made known their astonishment at the evidence they have found to the contrary in the course of their researches in the department of military literature. As Major May puts it, one only has to read the letters of Colonel Siborne to realise the extent to which soldiers studied their profession even in the earlier years of the century, difficult as it was frequently, no doubt, for them to secure the books which were necessary to enable them to prosecute their studies. Major May puts the matter thus:—

> "When fighting on a grand scale was constantly going on and our opponents were the greatest military nation of Europe, it would indeed be surprising if some of our officers, at any rate, did not give some thought to a science on which their lives depended. When the Union Brigade went tearing down the slope on D'Erlon's corps and the third line was not held back in reserve, did not Lord Anglesey blame himself, and that the more so because he admitted that he ought to have known better from previous personal experience in Spain? And did not the officers know that it was all wrong, too, just as well

as though they had passed for promotion? Certainly they did. In one of the letters I have just referred to there is a passage about this very incident which says, 'Every cornet knew what would happen.' And yet Von Bredow, in 1870, charged without supports, and his brigade was cut up just as was ours at Waterloo and for exactly the same reason. If Waterloo had been kept in mind would not the 6th Cavalry Division have been sent to his support? Will it not be of advantage to us if our future cavalry generals lay the lessons of military history to heart and, when they launch their squadrons, remember what happened to both Lord Anglesey and Von Bredow and profit by such experiences?"

Some may contend that in England the opportunities for professional study are limited, so much time being required for the proper understanding of those dry and not very practical details with which most of our guides to examinations are crowded. "But where there is a will," the old saying has it, "there is a way"; and there is no valid reason why British officers should be behindhand in their knowledge of past campaigns. What can be better for a young officer during a winter leave than a sojourn near the scene of some famous battle or series of battles? First he might read carefully all the best authorities and then go quietly over the ground itself upon which the battle or campaign was fought. This from a keen soldier's point of view would be spending a holiday agreeable and profitable. But how many do so? So far as Dr. Maguire and Major May are concerned their object is not, as we understand, to suppress or even limit the study of tactics, but to have the subject, if possible, studied to the best advantage. We quite agree with them. Military history has to a great extent been elbowed out; it is an immense pity that it should be so, but the fact remains that, generally speaking, much as our officer have advanced in a professional sense, they have not that general acquaintance with military literature which they ought to possess.

In the supreme crises of war there is no time as a rule for a man to waste over minor details; an officer has usually to act intuitively, to strike in accordance with broad principles. Such principles do not alter with equipment and armament; they are to be found laid down in military history, not in official red books. It is as well that young officers should understand this. It is to us a source of great satisfaction to find that efforts are being made to bring home to the rising generation of officers the immense advantage it would be to them if they were to read with an object. As Major May tells us, Napoleon was a close student before he became a great general. He has recorded his admiration for Turenne, and has stated that he (Turenne) had made himself what he was by a laborious study of the principles of war. It is on record that Wellington told General Shaw Kennedy that he had made a rule throughout his service to devote several hours daily to his professional study. Von Moltke has admitted how much he was indebted to the Great Frederick, and the young British officer, too, would find himself an immense gainer if he would read mark, learn, and inwardly digest from time to time such works as deal directly with the fighting aspect of his profession and not from those which lay down rules only for the purposes of the examination board.

—*Army and Navy Gazette, October* [illegible]

ARTILLERY MATERIAL.

a. Guns and Carriages.

Description of a 20 mm. (about 0.79 in.) caliber sub-caliber rifle tube m/95, for 24 cm. (about 9.45 in.) caliber, m/92 and 24 cm. caliber m/76 and m/75.

The sub-caliber rifle tubes consist of:

A *barrel* of steel (for the 24 cm. caliber m/70 and m/73 provided with a vent screw as indicated in Fig. 2); the bore has a caliber of 20 mm. rifled with 12 grooves, 0.25 mm. deep, and with a constant twist of 1 turn in 45 calibers.

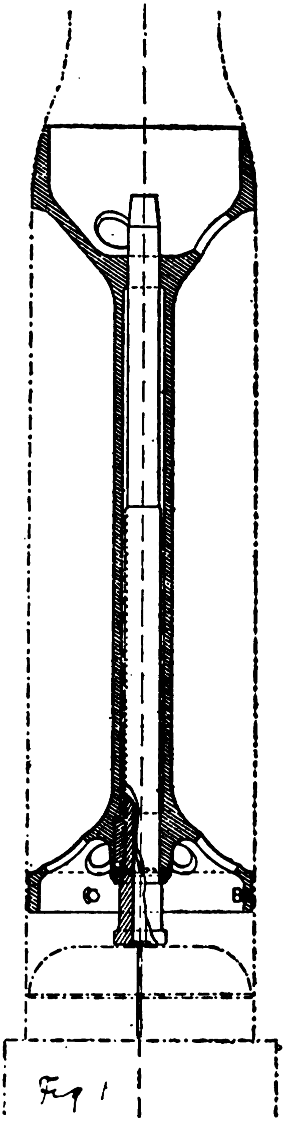


Fig 1

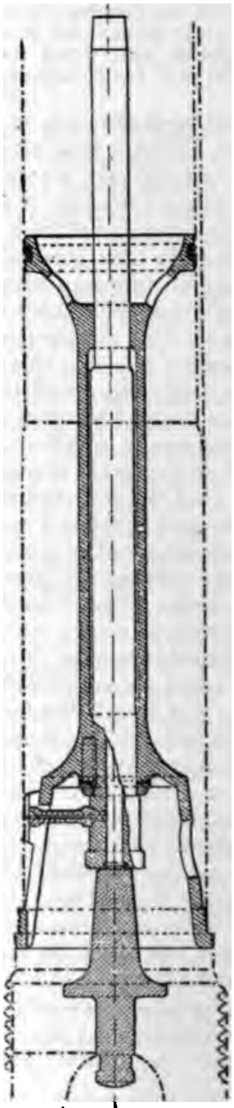


Fig. 2.

A *sheath* (or *scabbard*) of bronze fitting the chamber of the gun for the 24 cm. caliber m/70-73 (Fig. 2). For the 24 cm. caliber m/92 the usual breech block for the gun can also be used for the sub-caliber rifle (Fig. 1).

A *base ring* of steel.

rings of steel and brass, 6 different numbers of different thicknesses
o, 0.60, 0.75, 1.00 and 2.5 mm.).
w or pin fastening to prevent the barrel from turning.
s this there belong to it, a *screw key* for the set screws for the 24 cm.
1/92.
mer.
s with long and short handles; the latter to be used as a chamber

nce scale to be placed on the gun sight.
rojectile is of lead weighing 161.5 grams.
arge consists of 25 grams. musket powder, enclosed in a cartridge
hin silk. The length of the cartridge is 80 mm. and diameter 21 mm.
ject fired at should be on a reduced scale, and the range scale used
hould also be correspondingly reduced.

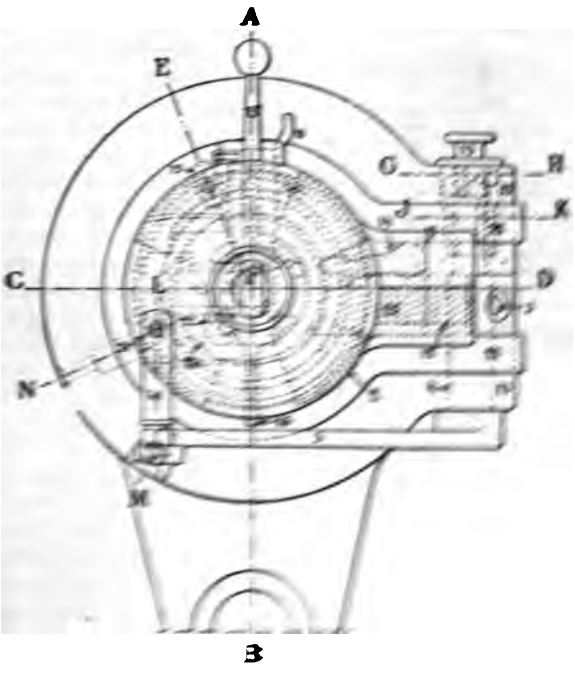
—*Artilleri-Tidskrift.*

ted by 1st Lieutenant J. A. Lundeen, 4th Artillery.]

The Bofors' Quick-Firing Mechanism.

nexed figures show the construction of the mechanism.
1 shows a rear view of the gun. Figure 2 is a vertical and longitu-
tion of the mechanism, when closed and the gun discharged. Figure
izontal and longitudinal section of the mechanism closed and the gun
ed, while figure 4 shows the mechanism, when the hammer is cocked,
over is not yet worked upon by the lever.
echanism consists of the ogival screw (1); the cover (2); the lever

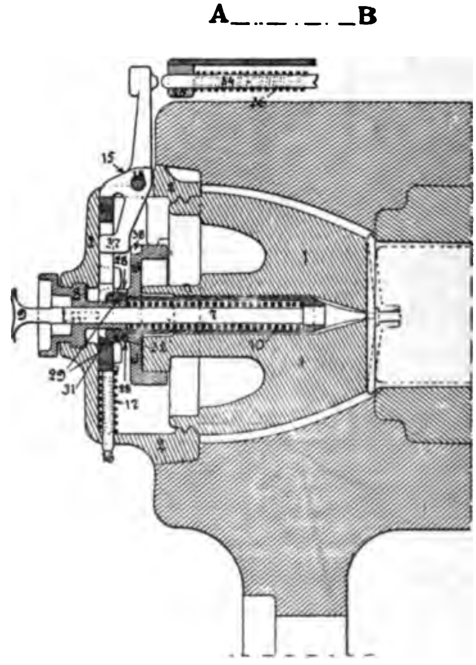
Fig 1



(3) with its spindle (4) and pin (5); the sliding carriage (6); the hammer (7) with locking stud (8), the handle (9) and spiral-spring (10); two toothed segments (11 and 12); the couplingbox (13); the extractor (14); the firing mechanism, consisting of the three-armed lever (15), the bar (16), the spiral-sprin (17) and pin (18); the bolt (19) with its spiral-spring (20) and the guiding pi (21).

The central point of the arc, which indicates the outlines of the ogival pa of the screw (1) is to be found on the geometrical axis of the spindle (4. Through this construction is gained, that the ogival screw, after being turne round its axis ⅛ of a turn, can be swung immediately aside, while with th cylindrical screw it is necessary first to extract the same a good deal, befor it can be swung aside. The ogival screw (1) is screwed into the cover (2) the threads of which have the same pitch as those on the ogival part of th screw. The right side of the cover (2) is provided with 2 lugs (22) which together with the spindle (4) and both the lugs (23) on the gun form a hinge. Upon the spindle (4) which is forged in one piece with the lever (3) an between the two lugs (22) of the cover, there are two toothed segments (and 12) of which the lower (12) always follows the motions of the lever, whil the upper (11) is independent thereof. For this reason also the central h of the toothed segment (12) is square as well as the part of the spindle (4) on which it is fixed, while the toothed segment (11) is provided with a cylindrical central hole. The latter segment (11) is on the contrary compelled to follow the motions of the cover (2) through the action of the coupling box (13) the lower part of which is hexagonal like the central hole in the upper lug of the cover (2) and the projecting clutches of which enter the 3 corresponding notches (24) in the toothed segment (11). The sliding carriage (6) is on its right end provided with some vertical teeth (25) gearing with the toothed segment (12) and on its left end with some horizontal teeth (26) which are engaging with corresponding teeth (27) on the ogival screw (1). The sliding carriage (6) is beside this provided with 2 sloping faces (28), which force the hammer (7) back, when the sliding carriage is moved to the right by the toothed segment (12). For this purpose the hammer (7) is provided with 2 shoulders (29) which always are behind the sloping faces on the sliding carriage, and the faces of which are sloping like those of the shoulders and therefore ought to be close to them. The extreme part of the slidin carriage (6) forms a projecting part (30), for which

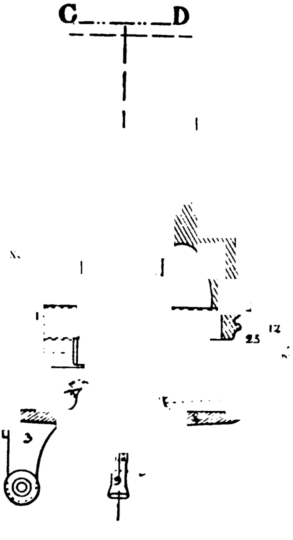
Fig. 2.



ı corresponding recess in the back of the ogival screw. Since the ırriage (6) is connected with the cover (2) by a coulisse-shaped ı which it, always keeping its horizontal position, can glide from o the other, it is evident that the ogival screw cannot move, as long ›jecting part (30) is in its recess in the ogival screw (1).

ing mechanism (fig. 2) works as follows. When the hammer (7) pon by the 2 sloping faces (28) on the sliding carriage (6), is forced spiral-spring (10) is pressed, because the rear part of this spring nst the locking stud (8), which in its turn is fixed in the cover by a so called bayonet-lock. Moreover the rear end strikes against the on the bar (16), which thereby is pushed down, until the catch falls otch (32), by which the bar (16) rises a little, through the action of -spring (17), and thus keeps the hammer (7) in cocked position. The ed in the following manner. By moving the upper branch of the ed lever (15) backwards the horizontal branch descends and presses 6) down. Its catch will then slip away from the notch (32), whereby ıer (7) is thrown forward by the spiral-spring (10). The hammer (7) strike the primer at the bottom of the cartridge-case. The three- ver (15) may be worked upon by means of a lanyard, fixed in its l, but in order that e man who discharges the gun may be able to eye in the line of sight, another arrangement may be made use of antage. This consists of a trigger (33), fixed to a firing-bar (34), 3 small bearings (35) is fixed on the under side of the curved plate vers the rear part of the gun and which is attached to the cradle. ound the rear part of the firingbar (34) a spiral-spring (36) is placed, nstantly presses the firingbar (34) forward. If the trigger (33) is ackwards, the firingbar (34) is also moved back, whereby it touches r end of the three-armed lever (15). It is to be observed, that this cannot be moved unless the lever (3) is fully home, *i. e.* unless the m is completely closed. The reason for this is, that the lower end (37) of the three-armed lever (15) always is in contact with the sliding carriage (6), as long as the latter is not in the position it occupies, when the mechanism is fully closed. On the contrary if the sliding carriage (6 happens to be in this position, a notch (38) in the rear side of the sliding carriage (6) is also at the same time opposite the lower arm (37) of the three-armed lever (15), whereby the lever is free to rotate around its pin (18). The firing mechanism acts therefore at the same time as a safety arrangement against premature discharge. But after the gun

Fig.3'



is ready for fire, it is necessary to prevent, that the lever (3) not through any accidental circumstance may be moved backwards, before the gun is fired, as this would make the discharge impossible. For this reason the lever (3) is supplied with a lock to secure it to the gun. On a projection forged in one with the lever (3) there is underneath applied a small hook (39), which can rotate around a pin (40). At the rear end of this hook the handle (41) itself is placed, which is pressed upwards by a spiral-spring (42), while the fore end of the hook is pressed downwards and drops into another hook (43) fastened to the gun. At the almost involuntary pressure downwards by the hand, which will arise, when one grasps the handle, the hook (39) is raised out of the hook (43), whereby the lever (3) is made free. On the contrary when at the closing of the mechanism, the handle (41) is let go, the hook (39) drops into the hook (43) and keeps the lever (3) locked to the gun.

The extractor (14) is provided with a hook, which grasps the edge of the cartridge-case. The extractor is lodged in a groove in the metal of the gun, in which it can glide backwards and forwards. On its outer side the extractor is provided with some teeth, which engage with the toothed segment (11) that, being connected with the coupling box (13), is obliged to follow the movements of the cover (2). When therefore the toothed segment (11) turns in the direction indicated by the arrow (a), the extractor (14) is forced to move backwards, thereby drawing out the cartridge-case. In this way the extraction will never be violent, whereby it is not required to have a special arrangement for protecting the gun-crew against the otherwise rapidly ejected cartridge-cases, which is an appreciable advantage with the big guns. At the end of the rotating movement of the cover (2), the coupling box (13) rises automatically and is disconnected from the toothed segment (11), whence follows, that, when this segment now can rotate independently of any other part than the extractor, the latter follows, when the new cartridge-case is introduced in the chamber. When the mechanism is shut, the coupling box (13) lowers itself also automatically, which takes place just as the cover (2) has come in contact with the breech end of the gun, and connects anew the toothed segment (11) with the cover (2). These automatic up and down movements of the coupling box are produced by the aid of two small guiding pins and corresponding slots with oblique faces (fig. 10). One of these guiding pins is in the central hole of the upper lug of the gun and catches into a suitably shaped slot on the outer side of the cylindrical part of the coupling box. The other guiding pin is inside the coupling box and works into a correspond-slot at

Fig. 4

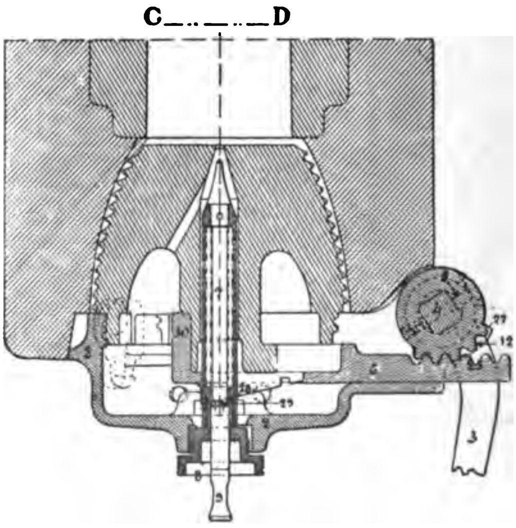


Fig. 5

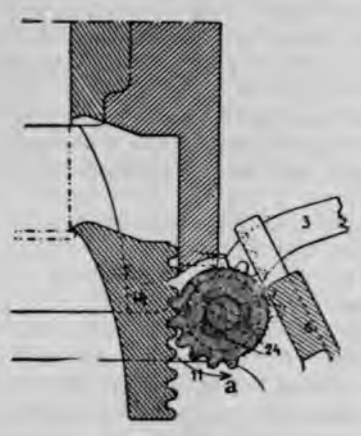


Fig. 7

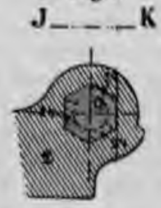


Fig. 6

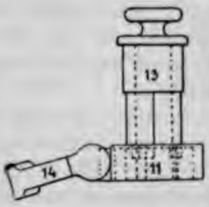


Fig. 9

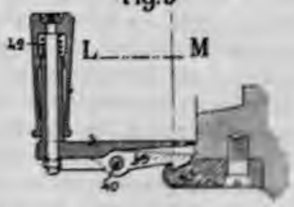


Fig. 8

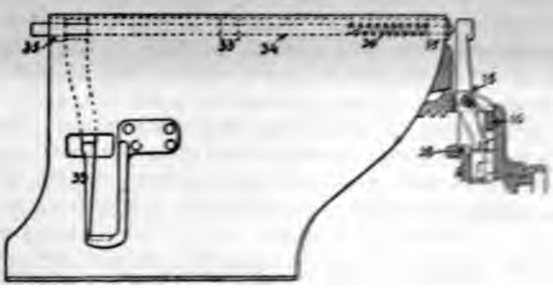


Fig. 10

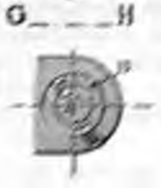


Fig. 11

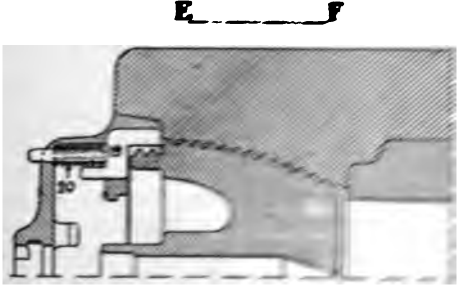


Fig. 12

the upper end of the spindle (4). If it should accidently happen, that the mechanism cannot be opened by the lever, through the cartridge-case sticking hard, the coupling box (13) has only to be raised a little by hand, after which the mechanism can be opened without difficulty. The cartridge-case can then in a suitable way be pushed out from the muzzle. This mechanism is probably unique in its way.

The bolt (19; fig. 11) is intended for securing the ogival screw (1) to the cover (2). From the moment the cover (2) does not lie close to the gun, the bolt (19), worked upon by its spiral-spring (20), enters a corresponding notch (45) in the ogival screw (1).

The guiding pin (21) has for its object to control the ogival screw during the commencement of the motions for opening the mechanism. It performs this part before the bolt (19) is ready to undertake it. The guiding pin (21) moves in a groove taken out in the metal of the ogival screw.

To protect oneself against the fatal consequences of a "hang-fire," the mechanism is fitted in a most original way. For this purpose one makes use of cartridge-cases, the bottoms of which, instead of being plane, are provided with a hollow about $4\ ^m/_m$ deep. Consequently the hammer (7) must be $4\ ^m/_m$ longer than if the bottom of the case were plane. When the shot goes off, the hollow in the bottom of the case is flattened through the pressure of the powder-gas, by which the hammer is moved back as far as the depth of the corresponding hollow in the bottom of the case. This motion of the hammer being a necessary condition for opening the mechanism, it is clear, that in case of a "hang-fire" or a miss-fire, it is impossible to open the mechanism before, in the former case, the shot finally has gone off, or, in the latter case, the hammer has been drawn back a little by hand. The means employed to prevent the opening of the mechanism too early, is very simple. For this reason there are 2 notches in the sliding carriage (6), which are opposite 2 small shoulders on the hammer (7), when the mechanism is shut. Consequently the aforesaid shoulders on the hammer enter the notches on the sliding carriage (6), when the hammer has been released, and lock the sliding carriage (6), until the hammer has been brought back, either through the effect of the powdergas, in case of a "hang-fire," or by hand, when a miss-fire has taken place. But as the mechanism cannot be opened if one cannot move the sliding carriage (6), it is evident, that this contrivance for protecting against "hang-fires," offers an exceedingly great safety. The hollow in the bottom of the cartridge-case does not in any way weaken the case, according to what has been proved by experience. Although used more than 10 times, the cases have been serviceable just as new ones, if on the whole they have been of good quality. One has nothing else to do but to refit the bottom of the case with the hollow after each round, which can easily be made by means of a special apparatus. In order to make it impossible to open the mechanism too early, one can no doubt also avail oneself of some mechanical contrivance, that acts by help of the recoil, but contrivances of this kind are neither so simple nor so certain of action as the above-named.

b. Armor and Projectiles.

Trials of Armor-Plates.

Recently there has been considerable activity at the works of our armor-plate constructors, with the view of improving the hardening process and the resistance of the plates, and quite a series of trials have been made on board the old Nettle at Portsmouth. Two of the plates submitted by Messrs. John Brown and Co., Limited, of the Atlas Works, Sheffield, were tested in the presence of Sir W. H. White, assistant controllor and director of naval construction, and of the captain of the Excellent; the principal object of the trial was to determine: "(1) Whether the surface cracks that are liable to occur in manufacture in the case of the most modern plates, are prejudicial to their resistance; (2) whether a plate that has been machined to a smooth surface before supercarburisation offers a better defense than one that has been carburised on the rugged surface as left from the rolls; and (3) whether a sort of fold, technically called a 'lap,' in the face of a plate causes a local or general weakness." It may at once be said that the results appear to show that the surface cracks did not affect resistance at all, even when the shot struck actually on them. That the advantage of the tedious and expensive process of machining all over the surface might be considered as affecting alone the appearance and economy in paint—both points to which some importance is attached—and that a "lap" in the face may be a source of weakness if a shot strikes exactly on it, but does not affect resistance under any other conditions, nor does it conduce to cracking.

Both the plates tried—the latter on August 10—were 8 ft. by 6 ft. by 6 in. thick, and were cut from a single larger one, which, after rolling, had been straightened and machined on one side to an even thickness of 6 in. The plate tested first—on July 20—had been supercarburised on the smooth side, and the other on the side that had not been machined. The subsequent treatment of the two plates was alike, and as the material was of new and special kind, the manufactures were not satisfied with making the plates flat in the first instance, as is usual with test plates, but made them originally concave, and then heated and bent them till they were slightly convex. This was done so that the plates might undergo all the processes that would be necessary if they were to form a part of a ship's armor, every plate of which usually requires to be bent, and some very considerably, with the hard side in tension. In the case of the first (the smooth-faced) plate this bending produced some superficial cracks in the face, but in the other it did not. The second plate, however, had a seam where the steel had lapped over itself slightly in forging.

The most recent Admiralty requirements are that a plate of the dimensions given shall resist five Holtzer steel projectiles of 6 in. in diameter and 100 lb. weight at 1960 foot-seconds striking velocity, without serious cracking, and it will be seen that these conditions were satisfied in both instances.

The first of the plates was tested on July 20. All the shot were completely destroyed, and the penetration obtained was slight (about 2 in.) except in the case of the one that struck in the upper left-hand corner, which at first was thought to have just got its fragments into the backing. When the plate was taken down, however, this was found not to be the case. The disc of the plate immediately opposed to the shot had yielded to some extent as if it had been a door hinged on the left side which the blow had partly forced open, but not enough to expose the backing, or let any part of the shot pass through. The other impacts had merely raised slight bulges on the back of the plate which was practically free from cracks. Some unimportant superficial cracks in the hard face were developed as the trial progressed, and one of those, from impact No. 2 to the left edge, appeared from the front to have gone through the thickness of the plate at that edge, but was traceable only about 2 in. deep

Official data of Messrs. J. Brown and Co.'s Armor-Plate tried on July 20, 1897.

Description.				Point of Striking.	Effect on Front of Plate.	Result on Back of Plate.	Effect of Striking on Projectile.
Round.	Gun used.	Charge.	Projectile, if a Shell, Weight of Burster.				
1*	6-in. B.L.	E.X.E. 48 lb.	Holtzer A. P. 100 lb.	2 ft. from right edge, 2 ft. from bottom	Size of injury, 13 in. by 10 in.; depth of injury, 2 in.; back of plate set back.	Size of bulge, 14 in. by 14 in.; height, 1¾ in.; semicircular crack on centre of bulge, and horizontal crack on top of bulge. Backing.—Size of indent, 14 in. by 14 in.; depth, 1½ in.	Broken up, point embedded in plate; point of core ¾ in. in front of face of plate.
2†	"	"	"	2 ft. from left edge, 2 ft. from bottom	Size of injury, 15 in by 14 in.; back of plate set back locally; surface scaling around round 1; hair line from round 1 to round 2; point of projectile of round 1 jared out.	Size of bulge, 13 in. by 13 in.; height, 1 in. Backing.—Size of indent, 13 in. by 13 in.; depth, ⅞ in.	Broken up, point embedded in plate; point of core 1 in. in front of face of plate.
3†	"	"	"	2 ft. from left edge, 2 ft. from top	Size of injury, 15 in. by 13 in.; size of hole, 7 in. by 7 in.; edges of hole smeared; crack showing from round 2 to left edge of plate.	Size of bulge, 9 in. by 12 in.; height, 5½ in. Backing.—Size of indent, 9 in. by 12 in.; depth 5½ in.	Broken up, remains of projectile remaining in the hole.
4†	"	"	"	2 ft. from right edge, 2 ft. from top	Size of injury, 10 in. by 12 in.; back of plate slightly set back; hair line from round 3 to top of plate; hair line from rounds 1 and 2 developed; point of projectile of round 2 loosened.	Size of bulge, 10 in. by 10 in.; height, ⅛ in. Backing.—Size of indent, 10 in. by 10 in.; depth ¾ in.	Broken up, point embedded in plate; point of core 1¾ in. in front of face of plate.
5†	"	"	"	Delivered at a point where hair line was showing at centre of plate	Size of injury, 14 in. by 12 in.; surface cracks between rounds 1 and 5, and rounds 3 and 4; hair line from round 3 to top of plate developed; cracking to the right of and below round 1; vertical crack 15 in. long and 10 in. to the right of round 5; point of projectile of round 2 jarred out.	Size of bulge, 12 in. by 12 in.; height, 1 in. Backing.—Size of indent, 11 in. by 11 in.; depth, ⅝ in.	Broken up, point embedded in plate; point of core 1¾ in. from face of plate.

Remarks.—* M.V. 1960 foot-second. † M.E. 2663 foot-tons.

when the plate was taken down. One of the superficial face cracks previously alluded to, as produced in this plate at the bending stage of manufacture occupied a position in the centre, and the fifth round was carefully aimed to strike exactly on it. It did not appear to influence the result in the least, nor did it, or any of the other original surface cracks, show any signs of extension during the trial. The official details of the trial are given in the above Table.

The second plate, which presented its rough side to the attack, was tested on August 10. It displayed a "lap" running horizontally across its width through the usual positions of impacts 1 and 2 (but in this case of impacts 1 and 3.) The first round was made to strike exactly on it, and the fact that this shot alone out of six got its fragments just into the backing, seemed to show that the plate along the actual line of the "lap" was weakened by it. The second round was fired at the centre, and made, in common with all the other rounds, only a shallow indent. To determine whether the weakness caused by the "lap" extended beyond its immediate situation, the third round was aimed just to avoid it by about an inch, and from the result it was evident that the weakness was absolutely local, and that the "lap" had no tendency to produce cracking whether the blow was actually on it or very nearly so. Indeed, the face of the plate after six rounds showed no cracking whatever beyond a few superficial hair lines, and it is to be expected that when its back is seen, it will show five slight bulges, one hole (where the "lap" was struck) and no cracks. The information derived from those two trials on the experimental points referred to, is of considerable value, and the general result was very satisfactory.

—*Engineering*, September 3, 1897.

A Test of Krupp Armor.

In a recent reference made in *The Iron Age* to a test of a Krupp armor plate, the statement was printed that the plate in question was through cracked at the fifth shot. This was a mistake, since there were only surface cracks, quite a common appearance on surface hardened plates. Besides, the penetration of round five was only 4.1 inches, and not 7.7 inches as stated. It may be noted also that after the fifth round four additional rounds with 8-inch and 6-inch armor piercing shells were fired at the tapered part of the plate without cracking it. The point is made that the effect of round five does not give a correct idea of the power of resistance of the plate, since the points of impact of rounds one and five were too close together, their centers being only 16 inches apart. This part of the plate, therefore, had certainly lost the better part of its power of resistance before being struck by round five. The other points of impact were very close together, being about two feet apart from each other and from the edge of the plate. —*The Iron Age*, July 1, 1897.

c. Powder and Explosives.

Trials of Smokeless Powder, Manufactured by Max von Förster, Berlin, fired from Krupp's cast-steel 8.7 cm. Turkish field gun, on the proving grounds of Tshataldja,, near Constantinople, August, 1897.

Weight of shell, 6.210 kg.

Temperature of air + 29° C.

Powder (smokeless) charge:—0 570 kg., velocity 25 m. in front of gun 446 m.; 0.580 kg., velocity 25 m. in front of gun 454 m.

Difference between greatest and lowest velocity 7.4 m.

To obtain this velocity the regulation charge of the old smokeless powder would be 1.5 kg.

The gas pressures obtained were considerably lower than those caused by the old gunpowder.

The smokeless powder left no residue in the bore. No unconsumed powder grains (leaflets) remained in the bore nor were any found in front of the gun. Very little smoke. On opening the breech-block immediately after firing, no flame in rear, a moderate one in front of the gun.

The following tests were also made:

Firing for accuracy gave good results.

An endurance test of 75 shots, in order to determine whether the powder exerts any deleterious effect on the gun, particularly the bore. The 75 shots were fired in 1½ hours. After every 15 shots the bore was washed out and examined.

After the firing was completed the bore was carefully inspected and measured. No alterations were observable nor any deleterious effects.

Firing with powder artifically dried and kept at + 55° C., also with powder exposed to very moist air. No abnormal shots resulted, although the pressure, in case of the warmed powder, was higher.

The chemical examination of the powder showed good stability in the acid test with zinc-iodide and starch paper, and a sufficiently high temperature of ignition, so that it could be definitely assumed that the powder will withstand all climatic action for many years.

No ingredients other than nitrated cellulose (guncotton) are found in the powder.

In conclusion, the trials showed that the smokeless powder furnished by the factory of Max v. Förster for the Turkish artillery, conformed to the conditions laid down for the delivery of the powder, and that it has no deleterious action on the guns.

—*Deutsche Heeres-Zeitung*, September 22, 1897.

Trials of Smokeless Powder.

Weight of shell. kg.	Charge of powder. kg.	Pressure in atmospheres.	Velocity 50 m. in front of muzzle.	Initial velocity. m.	REMARKS.
7.020	0.535	1352	435		Temperature of air + 21° C.
		1362	436		Barometer 763.
		1372	437	444	Hygrometer 60%.
		1356	436		Moisture of powder 2%.
		1370	437		
	Mean:	1362	436		
	0.550	1460	444		In firing, very little smoke, no residue, no unconsumed grains in the bore and none in front of muzzle, no flame on opening breech-block, a moderate one in front of muzzle.
		1452	449		
		1444	443.5		
		1426	443.5		
		1468	443		
		1439	443		
		1430	444		
		1452	445		
		1444	444		
		1426	443		
	Mean:	1444	444	452	
	Greatest difference:	42	6		

Trials of smokeless powder, composed only of nitro-cellulose (gun-cotton) and manufactured by Max von Förster, Berlin, fired from the heavy field gun C/73 (Krupp's 8.8 cm. cast-steel gun), July 1897, at the factory's proving grounds (see preceding table).

During the past months 150 shots were fired from this same gun, without any effect on the gun, especially the bore. The powder does not strain the pieces (Krupp's cast-steel guns) any more than does any other smokeless powder, indeed, the strain is less than with the old gun-powder, since the same initial velocity is attained with less gas pressure.

—*Deutsche Heeres-Zeitung*, September 4, 1897.

FORTIFICATION.

The United States and Spain.

One of the first questions which naturally presents itself as of paramount importance to both sides, in the event of possible complications between Spain and the United States, is the relative and comparative position of these two powers as regards naval strength and value of coast defenses.

At first glance it would appear that Spain has chosen an inopportune moment to risk a conflict with the Great Republic of the New World. The United States has, since the year 1891, been putting forth every effort to overtake the general backwardness of her position as a naval power, which was the result of thirty years' absolute neglect of the fleet. In 1891 she did not possess a single battleship or cruiser, completed, of really satisfactory type. The most important vessels of her navy then approaching completion had been so long in building that they were practically obsolete, and the battle ships and cruisers of the new naval programme were not even laid down.

Battleships and armoured cruisers.	Displacement. Tons.	Speed. Knots.	Armor. In.	Heavy Guns.	Light Guns.
Brooklyn	9,250	21.9	7½ to 8	20	20
Indiana	10,288	15.5	18 to 6	16	30
Iowa	11,410	16.1	14 to 15	18	30
Katahdin (ram)	2,150	16.1	6 to 18	—	4
Maine	6,682	17.4	12 to 10	10	20
Massachusetts .	10,288	16.2	18 to 6	16	30
Monterey . . .	4,080	13.6	14 to 10	4	12
New York . . .	8,200	21.0	10 to 4	18	16
Oregon	10,288	16.7	18 to 6	16	30
Texas	6,315	17.0	12	8	22
Cruisers.			*Protected Deck.*		
Baltimore . . .	4,600	20.6	4 to 2½	10	14
Bennington . .	1,750	17.5	—	6	9
Boston	3,189	15.0	1½	8	12
Charleston . . .	4,040	18.7	2	8	14
Chicago	4 500	18.0	4 to 1½	14	16
Cincinnati . . .	3,183	19.0	2½	11	14
Columbia . . .	7,475	22.8	4 to 2½	11	20
Concord	1,700	17.0	—	6	9
Detroit	2,000	18.71	3	9	10
Marblehead . .	2,000	18.94	3	9	10
Minneapolis . .	7,475	23.00	4 to 2½	11	20
Montgomery . .	2,000	18.87	3	9	10
Newark	4,083	19.0	—	12	17
Olympia	5,800	21.69	4¾ to 2	14	24
Philadelphia . .	4,413	19.68	4 to 2½	12	17
Raleigh	3,183	19.0	2½	11	14
San Francisco .	4,083	20.2	3 to 2	12	17
Helena	1,392	13.0	2½	8	10
Wilmington . .	1,392	13.0	2½	8	10
Yorktown . . .	1,703	17.2	—	6	9

Since then, however, progress has been very rapid, the result being that at the present moment the United States can command, roughly, the above naval force of seagoing vessels.

In addition to the above, several powerful gun vessels of 1000 tons and over, of slow speed, are either building or just completed, and a number of older coast defence armoured vessels and older cruisers are on the lists, but we have only included the most recent and powerful warships. The torpedo boat flotilla is of no importance.

In order to rank against the above list of ten battleships and armored cruisers, and twenty ordinary cruisers, Spain can only show the following slender proportion of seagoing vessels actually completed and afloat, although a large number of ships have been laid down or launched within the past three years:

Battleships and armored cruisers.	Displacement. Tons.	Speed. Knots.	Armor. In.	Heavy Guns.	Light Guns.
Almirante Oquendo . . .	7000	20	12 —10½	12	18
Emperador Carlos	9235	20	10	14	12
Infanta Maria Teresa . .	7000	20.25	12 —10½	12	18
Numancia	7305	8	5½	16	8
Pelayo	9900	16	17¾—19½	17	18
Vizcaya	7000	21	12 —10½	12	18
Cruisers.					
Alfonso XII.	3090	17½	—	6	17
Alfonso XIII.	5000	20	4½	10	15
Lepanto	4826	20	4¾	10	15
Reina Christina	3520	17.5	—	6	15
Reina Mersedes	3090	17.5	—	6	15
Marques de la Ensenada	1030	15.0	2½	4	9
Conde de Venadito . . .	1130	14	—	4	9
Don Antonio de Ulloa . .	1130	14	—	4	9
Don Juan de Austria . .	1130	14	—	4	10
Infanta Isabel	1130	14	—	4	9
Isabel II.	1130	14	—	4	9
Isla de Cuba	1030	16	2½	4	8
Isla de Lozon	1030	16	2½	4	8

The cruisers of 1130 tons, which we have included amongst the Spanish vessels, are placed in the list because there are so many of them, but individual vessels of more importance are left out in the United States list. Spain has also a number of fast torpedo gunboats, a class which is not represented in America. She has also fourteen first class torpedo-boats built, and six building; two "destroyers" built, and four building.

As we before remarked, the first glance is very unfavorable to the relative strength of the seagoing Spanish navy when compared with that of the United States. Only eleven ships of real importance as regards tonnage and armament can be found to rank against the thirty which hail from the other side of the Atlantic. The superiority of Spain as regards her torpedo boat flotilla might give her a slight advantage upon the shores of her own continental dominions, as well as in the harbors and roadsteads of her island possessions. But she would be hopelessly outnumbered and overpowered at sea. A glance at the rates of speed, armament, and armored protection of the United States battleships and cruisers shows that individually and collectively the ships are immeasurably more powerful than those of Spain. So that it is quite clear that the command of the sea would fall into the hands of

America. That is to say, that if the two fleets were to meet at sea Spain would get the worst of it.

But this is a very limited view of the expression "command of the sea." In its fullest integrity this term implies that the Power which possesses such an attribute must have command of all seas in the vicinity of its territory. Look, however, at the vast extent of seaboard possessed by United States. The most enthusiastic Yankee could never conceive that all these countless leagues of coast line could be protected and patrolled effectually by thirty sea-going war vessels; independently of the fact that a large number of them is required for foreign stations, so that the figures given have to be greatly discounted.

Here, then, comes in the question of coast defences. What are the relative positions of the United States and Spain in regard to this rather important point? It is true that a very ambitious programme was issued in the States about two years ago, which provided for an enormous outlay on heavy guns and coast service howitzers to be mounted in batteries that should effectually seal the entrances to harbors and estuaries. But hardly any portion of the programme has been carried out. At San Francisco a number of pneumatic dynamite guns—seven, we think—has been mounted in emplacements which command the approaches, to supplement the existing batteries of coast guns and howitzers; but these last are said—on the authority of an officer of great experience in the United States—to be of the most inadequate description and worthless for defence; whilst the pneumatic "torpedo-thrower" is an untried weapon, so far as actual war service is concerned. The approaches to New York are protected by two or three batteries of heavy guns; but the position might be shelled with impunity in the absence of the fleet by vessels carrying long range guns; and the damage which might be inflicted upon the city and suburbs of New York would be immeasurably greater than the risk which the enemy might run of losing a vessel or two during the operation. It has always seemed to us to be a most unwise thing for the Government of the United States to be on bad terms with a Power possessing squadrons of any importance, whilst her coast remains practically unprotected, and her fleet has hardly emerged from the embryo condition. She is a great deal too vulnerable to be quarrelsome, and the only wonder is that the United States has not received a sharp lesson from one of the European Powers long ago. She has deserved it over and over again.

But, it may be asked, could not the Yankee fleet retaliate? And are not the coasts of Spain equally vulnerable? Certainly not. The 2122 kiloms. of coast line belonging to Spain, on the Atlantic and in the Mediterranean, are generally of the most inaccessible and rugged description, and the rivers which run down to the coast line are mostly of a rapid and torrential character, certainly not lending themselves to the entrance of a hostile fleet. And Spain has paid particular attention to the question of coast defence for many years. Perhaps no country has taken more [illegible] the perfection of coast battery protection, and she has had [illegible] from the most important gun-making firms of Europe as to [illegible] Santander, a very important port, is protected by four strong forts and Ferrol, which is the first naval arsenal in the kingdom, is surrounded with a [illegible] of forts and batteries, a system of detached forts [illegible]. Santona, although its defensive system is not yet [illegible] completed, is a port of great strength and importance. There are [illegible] other [illegible] well defended ports on the Atlantic coast. In the Mediterranean, the ports of Barcelona and Carthagena have the protection of outlying forts of considerable strength and importance, and Cadiz is a fortress of the first class, surrounded by immensely powerful works, such as the batteries of La Soledad and Boneti, San Sebastien, Cortadina de San Fernando, and Torre Garda. The reduction of these fortresses would necessitate the employment of a vast naval armament, and of siege batteries, fully equipped, and only a military Power of great magnitude could venture to undertake the work. The half-trained levies of the United States, that are at best only a militia of not very high order, are no match for the disciplined troops of Spain, 200,000 of which at least have had much recent fighting experience, and the United States Navy would be fully employed in meeting its enemy upon the high seas.

To sum up. Although in point of numbers of ships, weight of armament, armored protection, speed and other factors, the navy of Spain is certainly not equivalent to that of America, we are inclined to think that the United States would have more to lose than Spain in the eventualities of a naval war; and if a serious reduction of the Spanish continental fortresses was taken in hand it would prove to be a very long operation indeed. The fighting that Spanish troops have been recently engaged in would give a favorable preponderance to that side.

—*The Engineer*, October 1, 1897.

MILITARY GEOGRAPHY.

Floating Dock for Havana.

The continued presence of a large fleet in Cuban waters necessitated some means of repairing and painting the same, and the Spanish authorities found themselves called upon at short notice to provide some form of dock for their vessels, there being no repairing establishment of any kind in the neighborhood. The older fashion of stone graving docks was quite out of the question as, irrespective of their great cost, the time required for their construction was quite prohibitive. A dock large enough to deal with their largest ironclads would have taken three years in building, and perhaps longer, a somewhat similar stone dock at Cockatoo Island having taken no less than seven years to build, whilst the Gibralter one seems likely to take nearly as long. Their attention was therefore called to the new forms of ship-repairing machines, such as floating docks, and accordingly, at the end of last year, tenders were invited for the installation at the port of Havana of a floating dock capable of dealing with vessels up to 500 ft. long and displacing up to 10,000 tons. From amongst the different tenders set in, that presented by Messrs. Swan and Hunter, of Wallsend-on-Tyne, was the one accepted. This firm proposed a new form of floating graving dock introduced but a short time previously by Messrs. Clark and Stanfield in a paper read before the Institution of Naval Architects. The type had been introduced by this firm specially with a view to coping with the short and heavy ironclads of which modern navies are so largely composed, whilst still retaining the ordinary advantage of a floating dock in being able to take also light and long vessels such a liners and cruisers.

The dock, which was successfully launched last Saturday afternoon, consists of five rectangular pontoons, of which the two terminal ones have pointed ends. These pontoons are built of steel and are of great strength, as they carry along their centre line the whole weight of the 10,000-tons ship, which rests on a series of wooden keel blocks supported on transverse girders, which gradually transmit this local weight over the whole area of the pontoons. The five pontoons are fastened on each side by a very strong form of double-joint between two other caissons running one along each side, and which projects up above their decks, giving the whole dock a U-shaped section. These caissons or walls, as they are termed, bind all the five pontoons into one whole, and being higher than these they also regulate their descent below water, and afford the dock stability when it is lowered down to allow the vessel to float in over the keel blocks. It is in the upper chambers of these walls that the machinery of the dock is contained, and it is from their top deck that all the manipulations of the dock are carried on. That is to say that the valves that regulate the admission of water into the different compartments of the dock are worked from here, and the bilge shores and side shores which hold the ship up on the dock and keep it from heeling are hauled in and out and fixed in position from here. The length of the walls is 338 ft. 4 in. and their height 44 ft. 2 in., so that the dock can take a vessel drawing 27 ft. 6 in. and still have a freeboard of 4 ft. 2 in. The pontoons are each 11 ft. 8 in. deep, 88 ft. broad, and the aggregate length of the five is 450 ft. The length of ship, however, that the dock can take is not limited by its length, as there are no gates closing its ends, as in the case of the ordinary graving dock, but vessels of a much greater length than 450 ft. can be lifted, and in urgent cases floating docks have been known to lift vessels double their own length. End gates or caissons are, however, provided, which can be used with this dock when short heavy ironclads are dealt with, and by means of these the lifting power of the dock can be considerable increased, and, what is more important, longitudinal strains may be avoided, as the effort of lifting can be confined exactly to that portion of the dock which lies under the ship, so that the latter is as equally borne as if it were on the most solid stone foundation.

An interesting point about this dock is that electricity has been used as the motive power for pumping out the water from its compartments. The power is generated by two of Messrs. Scott and Mountain's compound vertical engines, each driving direct on to a Tyne dynamo. These engines are placed one in each wall, but the cables are so connected that either engine can send power to the opposite side in case of breakdown. From the diagrams the power is transmitted to five mortors in either wall, each of which drives by a shaft one of Messrs. J. and H. Gwynne's centrifugal pumps placed at the bottom of the side, which are of the centrifugal type but driving horizontally. Both motors and pump shaft are run on steel balls like bicycle bearings, so that there is but little friction. The power generated is sufficient to lift a vessel weighing 10,000 tons in 2½ hours, but it is one of the advantages of a floating dock that smaller vessels can be lifted in proportionately less time, and also at a proportionately less expenditure of power, being in this respect the direct opposite of a graving dock, where the smaller the vessel the greater the amount of water to be pumped. We have mentioned earlier the great advantage that this type of dock offers in the way of speed in building. The contract for the present dock was signed at the beginning of December last; the drawings and quantities had to be got out and the material ordered, whilst in this case special machinery was also put down, with the result that it was not until the beginning of March that the first plate was laid. The dock is launched in a fine condition, and in the course of next week will take its departure for Havana. Had it been intended for use on the Tyne it would have been capable of commencing its work and lifting ships within six months of the laying down of the first plate. It is hardly necessary to accentuate the advantage of time in the present case, or to point out how this compares with the time required to build a stone dock.

At the launch the Admiralty was represented by Sir William White, who made a careful survey of the dock, and it is possible that in this novel development of steel construction applied to docks they will find the solution of the problem of providing speedily and at a low cost the numerous docks so much required in all our foreign possessions.

The dock is expected to arrive in Havana within six weeks of her departure, when she will at once commence her regular work of docking vessels, so that within 11 months of the Spanish Government deciding on acquiring one of these modern machines they will be provided with one capable of dealing with the heaviest vessels in their Navy.

—*The Army and Navy Gazette*, September 4, 1897.

War Ships and Torpedo Boats.

The Italian Cruiser *Giuseppe Garibaldi.*

The Ansald ship-yards at Sestri-Ponente launched on the 27th of September last an armored cruiser, the *Giuseppe-Garibaldi*, built for the Italian government.

This new cruiser is in every respect similar to that which had previously been built at the same works, and which was turned over to the Argentine Republic, bearing the name of *Garibaldi.* It also resembles the *Varese*, launched on the 25th of July at Leghorn, at the Orlando ship-yards.

The *Giuseppe-Garibaldi* has a displacement of 6840 tons and the following principal dimensions:

Length	100 m.
Beam	18.20 m.
Draft	7 m.
Depth of keel	12.20 m.

The triple expansion engines work two screws; the boilers are of the Belleville pattern; with natural draft 8600 horse-power is developed, with forced draft with 13,000 horse power she will attain a speed of 20 knots.

The capacity of the coal bunkers is 1000 tons, besides a considerable supply of petroleum.

The armament comprises two guns of 254 mm. in two armored turrets, protected by masks turning with them; ten of 152 mm. rapid fire, in battery in the central redout; six of 120 mm., rapid fire, on the upper deck protected by masks, and lastly ten of 57 and ten of 37 mm., rapid fire, and two machine guns, Nordenfeldt, in the top.

Five submerged torpedo tubes.

—*Le Yacht*, October 16, 1897.

Launch of H.M.S. *Canopus*.

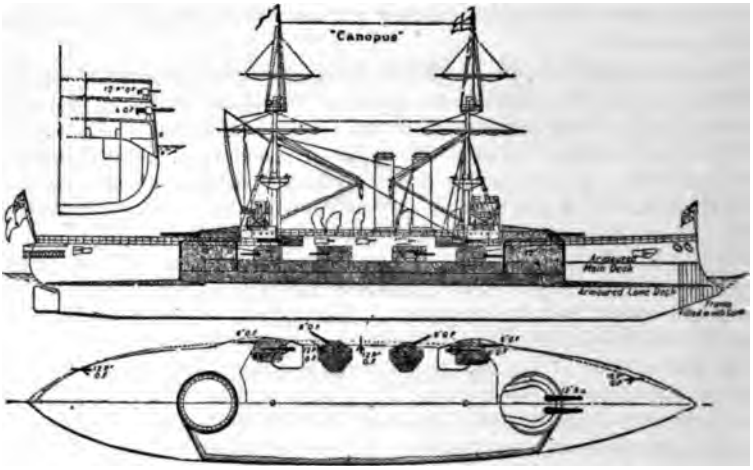
The first-class battleship *Canopus*, and the first of her type afloat, was successfully launched at Portsmouth upon Wednesday last from the famous old building slip which has borne the cradles of the *Trafalgar*, *Vulcan*, *Royal Arthur*, *Eclipse*, *Prince George* and *Gladiator*.

This vessel is one of a new class of battleships, designed by Sir W. H. White, K.C.B., three of which are building in the Royal Dockyards, and three by contract. They were originally called "improved *Renowns*," as their designed displacement approximated most nearly to the tonnage of that ship, but their disposition of armor, armament, and internal arrangements correspond more closely to those of the *Cæsar*, and they will somewhat resemble that battleship when completed.

The dimensions, etc., are as follows: Length between perpendiculars, 390 ft.; ditto over all, from taffrail to ram point, 427 ft.; beam, extreme, 74 ft.; mean draught, 26 ft.; displacement, 12,950 tons; speed, estimated, about 18.5 knots. This last will probably be exceeded by at least one knot. The *Canopus* will be fitted with twin screws, each driven by an independent set of triple-expansion engines, built at the Greenock Foundry, with three vertical cylinders of the collective horse-power of 6750, giving an aggregate indicated horse-power of 13,500 for both sets of engines. The boiler safety valves will be loaded to a pressure of 300 lb. per square inch, the steam pressure being reduced to 250 lb. per square inch at the engines. Unlike those in vessels of the *Majestic* type, the boilers will be of the Belleville pattern, the first to be fitted in any of H.M. battleships. They will be twenty in number and will be completed with all the latest improvements. Each boiler will be capable of being used independently of the others. The ship has bunker capacity for stowing 1900 tons of coal; her coal supply at load draught will, however, be only 800 tons. Her launching weight was about 4500 tons, none of the side or barbette armor being in position as yet.

The disposition of the protective armor is, as before remarked, similar to that of the *Majestic* type, combining the advantages of the turtle-back decks of the cruisers with those of the citadel armor of previous battleships. The vertical armor varies in thickness from 12 in. to 6 in., and is formed of steel plates treated by the Harvey process, which greatly increases their resistance to penetration. Protection is afforded by this armor to the machinery, guns, &c., as well as by an armored deck extending from stem to stern, which is 3 in. thick in the stoutest flat part. Thus the vitals of the vessel are shielded by an equivalent of 12 in. of specially prepared steel—the sloping 4 in. flanks of the armored deck giving an auxiliary thickness to the vertical 6 in. armored walls of 6 in.—and 12 in. of such steel with a hardened face will stop the 12 in. projectile, or break it up, being equivalent in stopping power to 30 in. of wrought-iron. The barbettes are covered with 12 in. Harveyed steel plates, so that their armor is equivalent to that of the side armor and oblique armored deck combined.

But another increment of protective strength has been afforded to this vessel by an armored main deck, extending also from stem to stern. This has two 20 lb. steel plates worked upon it, in lieu of the ordinary sheet steel, making a thickness of 1 in. altogether, independently of the turtle-back lower deck underneath. The vessels of the *Andromeda* class and many French ships have been treated in this manner, the only difference in the foreign ships being in the circumstance that they have the thick deck above and the thin one below, whilst we reverse the positions of the two. Advantage has been taken of the alteration in the main deck and of the teaching of the battle of Yalu to eliminate wood altogether from this deck. There is, therefore, no wood planking upon this feature of the *Canopus;* the 1 in. armor is now a smooth expanse without a rivet-head showing, but it is to be sheathed with composition for walking on. The forward conning tower, which is covered with 12 in. steel plates, does not stand over the thin end of a pear-shaped barbette, as in the *Majestic* and *Magnificent.* But the barbette being round, as in the *Cæsar*, a separate armored stalk is provided beneath the conning tower which carries the voice tubes and other gear to be connected.



H.M.S. CANOPUS

A special feature of the *Canopus* type is the ram bow, the point of which much higher than in former battleships, being only 7 ft. 6 in. below the su face of the water at normal draught, so as to deliver a blow to the ene immediately below the armored belt. The forefoot comes away at an abru angle from the keel, 45 ft. horizontally from the ram point, the flat keel ris from a spot just forward of one of the main bulkheads, and running straig to the ram, as will be seen by a reference to the profile engraved. T armored deck, which has a perfectly horizontal outer edge on either bea from stem to stern, is worked into the cast steel stem a very short distan above the point, and an ordinary flat, terminating in a stiffening plate of ste 2 in. thick, is bedded into the point itself. The whole of this portion of th bows is, moreover, to be covered with 2 in. nickel-steel armor plates over th ordinary skin. None of this armor is in position yet, but the rabbet in which it will fit can be seen running up the stem on both sides. The ram i therefore, with its associated parts, a solid cellular mass, extending to a ma bulkhead about eight frames from number "o," which is the first, and materials are stiff as well as elastic, the whole being supported by the ca steel stem, by the armored deck, by the stiffening plate beneath, and by th 2 in. nickel-steel armor plates, as well as by the ordinary skin and framing the ship at this spot.

About nine of the forward frames are webbed right across with thin stee plates, so as practically to constitute a series of bulkheads at 3 ft. interv The spaces between are filled in with cork, from the keel below to the ma deck above, as shown in our profile, a device already employed in th *Inflexible*, the *Colossus* and *Edinburgh*. It may be remembered that the thre battleships of the United States now under construction, the *Wisconsin* an her sister vessels, described in the pages of *The Engineer* some months ago, have large spaces behind the ram filled in with corn-pith cellulose, so that th American and British war vessels assimilate in this respect.

Two steel masts will be fitted, each completed with a fighting top; these latter will carry three 3-pounder quick-firing guns, with the necessary magazines and equipment. Above the fighting top an electric light platform will be fitted to each mast for working powerful search-lights. The topmasts are different to those of the *Majestic* class, and are so arranged that they can be readily lowered or housed at sea or in action. The main topmast is fitted with a semaphore for long distance signalling.

A steel derrick, 65 ft. long, will be fitted on the mainmast for lifting the heavy boats into their positions on the skid beams, steam winches being provided for working this. On the foremast a wood derrick will also be fitted for lifting the lighter boats and for coaling purposes. Temperley's patent transporters will be supplied with these derricks for coaling. Sixteen boats will be carried, including three steamboats; two of the latter will be capable of acting independently of the ship for purposes of torpedo attack, being fitted for discharging 14 in. Whitehead torpedoes, and, in the case of one of them, the spar torpedo in addition. Four of the lighter boats will be carried on davits, so that they may be quickly lowered when required for use as lifeboats.

Six search-light projectors, worked by three dynamos, each of 600 amperes, 80 volts, will be carried; and to complete the protection against torpedo attack the vessel will be fitted with the latest system of net defence. Provision will be made for lighting the ship throughout by electricity; Colomb's lights will also be fitted for service in case of a breakdown of the electrical apparatus. Eight electrically-driven fans will be fitted for the purpose of ventilating the working and living spaces which cannot be dealt with by natural ventilation; two steam fans for the ventilation of the engine rooms and five steam fans for the boiler rooms will also be supplied. A complete system of voice pipes will be fitted throughout the ship, to enable orders to be transmitted from the protected look-out positions to the various fighting stations. These are associated with automatic water-tight doors where they pass through the armored deck, which close the apertures immediately after they have been opened for use.

Upon completing, the *Canopus* will be commissioned with a compliment of 750 officers and men. This ship has been built under the supervision of Mr. Lemon, foreman of the yard, acting under the instructions of Mr. Beaton, R. C. N. C., on the staff of the Chief Constructor, Mr. John Yates, R. C. N. C. Her keel was laid in January last. She has, therefore, been only nine months building—a *record* period.

The armament of the *Canopus* will consist of four 12-inch wire-wound breech-loading guns, twelve 6-inch quick-firing guns, ten 12-pounder quick-firers, six 3-pounder Hotchkiss guns, one 12-pounder 8 cwt. boat's gun, one 12-pounder 8 cwt. field gun, and eight 0.45-inch Maxims. She will also carry nineteen Whitehead torpedoes, fourteen of which will be 18 inches, and five of 14 inches diameter. She will have four submerged torpedo tubes, one on either bow, and one on either quarter. We are delighted to say she will have no above-water tube, a modification which must give general satisfaction.

The 12-inch wire guns will be fitted in pairs upon two circular armored redoubts, one at each end of the ship, and they will be mounted on revolving turntables arranged to work either by hydraulic or hand power. Armored shields or "hoods" will be fitted to give protection to the guns.

The 6-inch quick-firers will be mounted in casemates, eight on the main deck and four on the upper deck, and protected by 6-inch Harveyized armor. The ten 12-pounder quick-firers will be mounted on the main and upper decks, the 3-pounder Hotchkiss in the fighting tops, the two other 12-pounder quick-firers on the forward shelter deck, whilst the Maxims will be fought from the bridges or boat decks. One important modification is in the arrangement of the forward and aft 6-inch gun casemates on the main deck. These are sponsoned out on both beams, so as to bring the guns clear of the vessels side even when they are trained axially, a position which is impossible for these guns in the *Majestic* and her sister ships. The end-on fire of the *Canopus* is much improved by this device, the striking energy in foot-tons, which is represented by five minutes' consecutive fire ahead or astern, being increased as follows:

Two 12-inch guns, four rounds each......................
Four 6-inch quick-firers, 25 rounds each................
Two 12-pounder quick-firers, 75 rounds each.........
Foot-tons 663,210.

Independently of the fire *forward* of the two 12-pounder guns on the shelter deck. The weight of metal thrown is nearly nine tons.

All casemates are protected above and beneath by double plating. The main deck forms a natural armored base to those casemates built upon it. This is a most important condition as affecting the fighting positions of the the ship between decks.

The original *Canopus* was one of the six prizes taken in the Battle of the Nile which reached England safely.

—*The Engineer*, October 15, 1897.

National Defenses, by Major General Maurice, C. B. New York: The Macmillan Company, 1897. Pp. 209. Price $1.00.

This little volume from the pen of one of England's leading military writers comes to us very opportunely, as we are now at a time when our own national defense is claiming more attention than at any previous period.

The author of course is treating the subject of the defense of the British Empire, and divides his subject into three broad heads, viz:

What have we to defend—against what have we to defend it—and with what means shall we defend it.

Under the first head is clearly brought out the unique geographical situation of the Empire, its enormous mercantile marine, and the consequent commanding influence of these factors in any system of defense.

In his analysis of the second subdivision the author devotes particular attention to the danger of attack from Russia through the northern frontier of India; and indeed the aggressiveness of Russia in Asia seems to be one of the most disturbing influences in European politics. The liability of English commerce to attack from swiftly moving cruisers is also ably discussed. But there is one source of danger to the British Isles, which, in the author's opinion, is not nearly appreciated, viz: invasion. For such a thing to be possible, it is not at all necessary that England should lose complete control of the sea. A temporary loss of supremacy in the English Channel would give the desired opportunity, even though the English fleets were everywhere else supreme—consequently it is maintained that England should have at home, a land force sufficient to meet and defeat any such attempt.

In discussing the last head the enormous advantage of England's naval supremacy in any combination of European powers is clearly set forth, as is also the absolute necessity of her maintaining that supremacy.

England does not and cannot attempt to rival European powers in the numerical strength of her armies. To offset this she must—to use the words of Sir Grant Duff's toast, quoted by the author—have "a supreme navy, an adequate army and an incomparable diplomacy."

But again and again throughout the volume our attention is called to the fact that in a government by the people, no system of defense can attain a maximum efficiency until the people themselves understand and appreciate its necessity.

C. C. W.

Life of Napoleon Bonaparte by William Milligan Sloane, Ph. D., L. H. D., Professor of History in Princeton University. Volume IV. New York: The Century Co., 1897. Complete in Four Volumes; per Volume, Cloth, $7.00; half Morocco, $8.00; three-quarter Morocco, $9.00; full Morocco, $12.50.

The fourth volume of Professor Sloane's great life of Napoleon has been issued, thus completing this magnificent work.

The events recorded in this volume are the disastrous retreat from Russia, the campaign of 1813, the retreat beyond the Rhine, the campaign of 1814, the fall of Paris, Napoleon's first abdication and his exile in Elba, his return to France, the campaign of Waterloo, his exile in St. Helena and his death.

The horrors of the retreat from Moscow are presented in graphic pen pictures:

"Next day the weary march began again; scarcely a word escaped the Emperor. He was pale, but his countenance gave no sign of panic; there was merely a grim, persistent silence. The enemy hung on flank and rear, harassing the demoralized column until it was more like a horde than an army. With numbed limbs and in the gnawing misery of bitter cold, the French straggled on. Men and horses died by the score; the survivors cut strips of carrion wherewith to sustain life, and desperately pressed forward, for all who left the highway fell into the enemy's hands. In some bivouacs three hundred died overnight; there are statements in the papers of officials which seem to indicate that in the struggle for life the weaker often perished at the hands of their own comrades. The half-crazed, frost bitten, disorderly soldiers of the French van reached Smolensk on the ninth, and on the thirteenth the remnants of the rear with many stragglers, came up and encamped. The heroes of the hour were Eugène and Ney. Ney's division had well-nigh vanished in their glory. Fighting without fear, and dying undaunted, they had saved the majority of the grand army which reached Smolensk; the other half had perished by the way. Eugène had taken a long circuit, but his division had lost fewer and was less demoralized than those of his colleagues. Murat's recklessness in fighting the Cossacks had resulted in the loss of nearly all his horses; his men arrived on foot."

The wonderful way in which the Emperor reorganized the army in a few months is told in language that has the ring and the force of the actions described. The campaign of 1813, with Napoleon's great victory at Dresden, and the end of the grand army at Leipzig, the great "battle of the nations," is described in powerful words.

The account of the campaign of Waterloo is most accurate in all respects. Bourmont's desertion and treason, Wellington's poor comprehension of Napoleon's fine strategy, the misunderstanding with Ney, D'Erlon's fruitless marches, Gneisenau's (not Blücher's) determination to effect a junction with Wellington for the decisive conflict, and Grouchy's incapacity for independent command, are set forth in clear language, and as now understood by the best students. The excuses for Grouchy's action are somewhat too charitable, however.

But it is in the treatment of the campaign of 1814 that the author, like the strategist himself, rises to his greatest height.

The closing chapter is a scholarly and philosophic essay on Napoleon's place in history, and constitutes a fitting conclusion to this splendid work. We quote from this last chapter as follows:

"Turning to the field of general history, there are certain facts, admittedly Napoleon's doing, which quite as certainly are among the most important factors of contemporary politics. Of themselves these would suffice to give him a high place in constructive history. In the first place he deprived England of the monopoly in what had long been essentially and peculiarly her political ideal. What was the basis of the long conflict between England and France to which Napoleon fell heir? * * * Nothing less than a passion for the ascendency of one of the highest forms of civilization throughout the globe, including both Europe and America. This Anglo-Saxon, political, commercial, religious and social conception was after the Napoleonic wars no longer confined to Great Britain. Thence onward the great powers of Europe have been chiefly concerned, aside from their care for self-preservation, in partitioning Africa and Asia among themselves; and this process is no sooner complete than they begin to murmur about the Monroe doctrine, and to cast longing eyes toward Central and South America. The state system which was once European has become co-extensive with the sphere on which we live, and this notion of world-domination so denounced when held by Napoleon has become the motive-power of every great modern civilization."

The closing words are these:

"Another page of history which remains to be written is that which shall record the influence of Napoleon, direct and indirect, upon the destinies of the United States. The astounding magic of his name in our country is partly due to a quality of the American mind, which makes its possessor the passionate and indiscriminating adorer of greatness in every form. The Americans are more French than the French in their admiration of power. But after all this is not the main reason for their interest in Napoleon. They are, dimly at least, aware of certain facts which have determined their history and made them an independent nation. Their first war for independence left them tributary to the mother-country, both industrially and commercially. It was Napoleon who pitilessly, though slyly and indirectly, launched them into the second war with Great Britain, from which they emerged with some glory and some sense of defeat, but, after all, with the tremendous and permanent gain of absolute commercial independence. In the second place, their purchase of Louisiana, though understood by only a few at the moment, revolutionized their system both inside and outside. That momentous step destroyed the literal interpretation of the constitution, hitherto enslaving a congress of jarring little commonwealths in the bondage of verbalism, because, though manifestly beneficent and necessary, it could be justified before the law only by an appeal to the spirit and not to the letter. Thenceforward Americans have steadily been enlarging their constitutional law by interpretation, and the apparent timidity of amendment which they display is simply due to the absence of necessity for revision as long as expansion by interpretation continues. But certainly quite as important as this was also the displacement, by the acquisition of that vast territory, of what may be called the national center of gravity. Until then the aspirations of Americans had been toward Europe; the public opinion of the country had until then demanded the largest possible intercourse with that continent compatible with freedom from political entanglement. Thereafter there was a change in their spirit: a continent of their own was open to their energies. For two generations their history has been concerned with exploration, with mechanical invention, and with solving the great problem of how to prevent an extension of slavery corresponding to the extension of territory. But nevertheless, steadily and vigorously two correlated concepts were propagating themselves: neglect of Europe, in order to expand and assimilate their recent acquisition; industrial exclusiveness, for the sake of this great home market which immigration, settlement, and the formation of new commonwealths was creating, not at the front door, but in the rear of the states stretching along the Atlantic. This resulted in a temporary 'about face' of the nation; and it is only now, when the prize of material greatness and of territorial unity has been secured, that the nation turns once more towards the rising sun, in order to get from older lands everything germane to its own civilization, and to assimilate these acquisitions, if possible, in realizing its own ideals of moral grandeur."

At the end of the volume is given a bibligraphy containing "the titles of such volumes as will assure the reader a complete view of Napoleon and his times from the best sources."

The magnificent illustrations are similar to those of the preceding volumes.

The work, as a whole, is recognized as the best life of Napoleon extant, and takes its place as one of the great works of history of this age.

J.P.W.

Napoléon en exil, par le Docteur Barry E. O'Meara. Introduction et Notes de Désiré Lacroix. Paris: Garnier Frères, 6 Rue des Saints-Pères. Two Volumes, Small Octavo, pp. 412 and 500.

Doctor Barry O'Meara, whose name is so intimately assoclaied with Napoleon's captivity at St. Helena, was born in Ireland in 1786. He was the son of a brave officer who served with Lord Harrington in America. He studied medicine and graduated at Trinity College, Dublin, entering the 62nd regiment as assistant surgeon at the age of eighteen, and serving first in the campaigns in Sicily and Egypt, and afterwards entering the Navy and serving on the *Victorious* during the American war. In 1815 he was under Captain Maitland's orders when Napoleon was received on board the *Bellerophon*, and being requested by the Duke de Rovigo to accompany the Emperor to Saint Helena as his surgeon, he accepted.

From the first he took notes of the daily conversations he had with the Emperor, and for security sent the manuscript to England as fast as it accumulated, publishing from them soon after Napoleon's death his "Journal," which was read with intense interest everywhere. In it he set forth the treatment which Napoleon received at the hands of Sir Hudson Lowe, the Governor of the island, besides giving a full account of the daily life and a complete reproduction of the Emperor's conversations on subjects of interest.

The publishers believe that after the lapse of more than half a century the work of Doctor O'Meara will be read with as much interest as on its first appearance. Nothing in the original text has been changed, but many explanatory notes have been added.

The journal opens in 1815, when the *Northumberland* sailed from Plymouth to take Napoleon and his suite to Saint Helena, and closes at the end of July, 1818, when he bade adieu to Doctor O'Meara.

Although the daily record necessarily refers continually to the injustice and persecution of the governor, it also contains the Emperor's views on events and persons, expressed in the familiar terms of ordinary conversation, and hence possesses the charm which the words of such a Johnson recorded by such a Boswell would naturally possess.

We can give but a few extracts to illustrate the character of the contents.

Speaking to the Doctor of the English nation he says:

"Your soldiers are brave, no one can deny that; but it is bad policy for you to encourage the military mania, instead of standing by the navy, which is the true power of your nation, a power which will always keep you strong among the nations. To have good soldiers it is necessary to be always at war.

"If you had lost the battle of Waterloo, continued he, what would have been England's condition? The flower of your youth would have been destroyed; for not a man, not even Wellington, would have escaped." I replied that Lord Wellington had resolved when the action began not to leave the ield of battle eecept as a dead man. Napoleon replied: "He could not have etired. He would have been destroyed with his army, if Grouchy had come nstead of the Prussians."

He gives many interesting sketches of the characters of the prominent men f the times, soldiers and statesmen, and often unfolds the characteristics of f nations and peoples in clear, incisive words.

"Of all the generals which I have had under me, Desaix and Kléber have hown the greatest amount of ability, especially Desaix, for Kléber loved lory only in so far as it brought him riches and pleasure. But Desaix loved lory for itself, and despised all else. He dreamed only of war and glory."

* * * * *

"Murat was the best cavalry officer in the world. There never were, I elieve, two such officers in the world as Murat for cavalry and Drouot for rtillery."

Napoleon often reverts to Waterloo. In discussing the political situation luring and after his last campaign he says:

"There is a diversity of opinions as to what I should have done. Some hink that it was my duty to fight till not a single man remained. Others aid that as fortune deserted me at Waterloo, my military career should have nded forever in that field. I think myself I should have died at Waterloo, perhaps even earlier. If I had died at Moscow I would probably have been onsidered the greatest conqueror the world has known. * * * I should have died at Waterloo; but when I sought death I could not find it. Men were killed at my side, in front, behind, all around me, but not a bullet for me."

Madam de Staël, Lord Cornwallis, LaFayette, Barras, Carnot, Castlereagh, Metternich, the Russians, the Prussians, the English, their characteristics and their future, and many other topics of general interest are discussed; but we must refer the reader to the original, and content ourselves with merely adding that, although much is familiar to the reader, there is matter of entertainment and profit on every page, from the account of the Doctor's first meeting with the Emperor on board the *Bellerphon* to the final adieu, and the post script to the letter commending the Doctor to his friends:

"S'il voit ma bonne Louise, je la prie de permettre qu'il lui baise la main."

J.P.W.

Ulysses S. Grant and the Period of National Preservation and Reconstruction by William Conant Church. New York: G. P. Putnam's Sons. 1897. Pp. 456. Price, cloth, $1.50, half Morocco, $1.75.

This volume forms a part of the series entitled *Heroes of the Nations*, and onstitutes a valuable addition thereto and one worthy of a place among the est. The author, who served in the Civil War, attaining the rank of brevet ieutenant-Colonel of volunteers, has been editor of the *Army and Navy Journal*, and has associated on intimate terms with many of the general officers of our army, should be well fitted for the task. The selection of Grant s the typical hero of the Civil War is without doubt just and appropriate.

The style of the book is popular and familiar, and the text is interspersed with many anecdotes. The interest is well kept up, and, in spite of the fact that the reader is traveling over familiar ground, his attention is fixed by new features in the landscape, as well as by new ways of calling attention to the prominent landmarks.

One of the commonest popular errors in regard to Grant is that he graduated very low in his class at West Point, whereas he passed very near the middle, and this, taken in connection with the fact that Professor Church intended to apply for him as instructor in mathematics, shows that he had sufficient ability in the opinion of those best capable of judging.

Another popular fallacy is the opinion that he had not shown any professional interest during his first service in the army, but in the Mexican War he showed remarkable energy and judgment for one so young, and was often praised officially by his superiors, indeed, he "was one of only two line officers mentioned by General Garland in his report upon the actiou of his brigade at Chapultepec."

His energy and perseverance are his great characteristics. While McClellan was suggesting to Halleck and Buell a rapid combined movement up the Tennesee and Cumberland, and Buell was claiming that it would take fifty thousand to sixty thousand men, Grant had already accomplished it with two divisions.

In the campaign of Vicksburg failure after failure, disaster after disaster, seemed only to steel him to his task. He was representative of the times even in his manner of conducting a campaign, identifying himself with the spirit of the people as no other commander of the army did. And from the moment he became Commander-in-Chief there was concerted movement throughout the field of war and a gradual but certain progress to the accomplishment of the end.

The military events are described with care, and are made interesting by means of innumerable incidents, which the author has gathered from various sources.

Mr. John Russell Young, the present Librarian of Congress, who accompanied Grant on his travels around the world, besides furnishing several interesting anecdotes which the author has incorporated in his work, tells us of Grant's familiarity with the campaigns of Frederick and Napoleon, which proves another point not usually considered, viz: that Grant was a student of military literature.

The author's description of the scene in the McLean house at Appomattox makes an interesting picture:

"The contrast between the chief actors in this historical scene at Appomattox was striking and significant. Lee was Grant's senior by thirteen years, and was graduated from the Military Academy fourteen years before him. His entire training had been in the military service, and he represented the exclusive element of the old army, who considered that deportment was as essential to a military character as a uniform. His dignity and reserve well became his handsome presence, and he looked every inch the soldier."

"Grant, who was thoroughly democratic in all his ideas and ways, was dressed on this occasion in a plain and well-worn uniform, and wore an enlisted man's overcoat covered with the dust of travel.

* * * * * * *

"Grant represented the principles of equality and human brotherhood that make America what she is; Lee was the type of a departing era, destined henceforth to take its place with the expiring traditions of royal and aristocratic pretension."

The series of the Heroes of the Nations is too well known to need comment here on the good work of the publishers in clothing the volumes. The present one is embelished with interesting portraits and good maps.

J.P.W.

avalry versus Infantry, and other Essays, by Captain F. N. Maude, R. E., Kansas City, Mo.: Hudson-Kimberly Publishing Co. 1896.

This volume constitutes No. 4 of the International Series edited by Major rthur L. Wagner, Assistant Adjutant General, now in charge of the Bureau Military Information, Washington.

The well-known English writer is at least frank and fearless in his expres- ons of opinions, and while his judgment may not always be sound, or in cord with the accepted views of the best authorities, his words certainly ve the ring of the true soldier, and will inspire the troop leader with a sire to do and dare.

Let us see what he says of modern cavalry charges:

"As modern infantry tactics stand, a square is an almost inconceivable for- ation; instead of it only long lines of more or less shaken skirmishers are be met with: and allowing that the point blank range of their weapons is od against the cavalry target for 600 yards, if held horizontal—a condition t often fulfilled, as experience prooves—yet even then I doubt whether the e to be confronted is either physically or morally greater than it formerly as. Besides, no one ever has proposed to send cavalry against absolutely nshaken infantry direct, and even if they did propose to do so, the conditions the modern battle-field, with its fire-swept zone 3,000 yards in depth, rend- s it next door to impossible to find such a target for them. What they have oposed is merely this: that cavalry should on occasion be prepared to arge even what appear to be unshaken infantry; for, till the experiment s been tried, no one can tell whether they actually are unshaken or not. If ey are not shaken, well, there will be no mistake about the result; if they e, equally there will be no mistake, but it will be the infantry that will find t what it means. But to get troops and leaders to risk so much, they must taught to ride fearlessly, and to have confidence in their own power; but r present umpire training is hardly the way to make them do so."

And of modern infantry attacks he says:

"And therefore, if British troops have faced, and faced victoriously, a eater storm of projectiles from old smooth-bore guns firing grape, and old iskets sending out 12 or 14-bore leaden bullets, they can equally well face ything that under modern tactical conditions they are likely to be confront- with—always provided their moral courage has not been previously npered with. They have faced such fire again and again; for instance, at dajos the fire of 14 heavy smooth-bore pieces, 18 and 24-pounders, raking em on either flank, did not stop them, though the obstacles in front did. In e Crimea, in the assault of the Redan, the converging fire of close on a ndred heavy guns, firing case, also failed to stop them; at Chillianwalla, braon, and later again at Lucknow, they had to face a storm of bullets and ape-shot far in excess of what modern repeaters at equal odds can ever ing to bear against them, and on all these occasions they were formed oulder to shoulder in the good old line. All these instances prove to me nclusively that British troops, trained to know how to die, and not how to oid dying, are capable of answering to any demands that may be made of em. Let us give our men the best weapons that money can procure by all eans, only do not let us teach them that death in itself is any the more terri- e because it is delivered by a .298 patent repeating nickel-coated bullet iven by smokeless and noiseless hypernitrated powder.

"A nation whose troops less than a century ago proved themselves capable of winning against losses of over 50% in individual cases, is capable of turning out equally good ones to-day, for the fighting instinct is the slowest of all to alter—always provided they are adequately trained; and if they are so trained, then nothing on the continent of Europe can defeat them—still less in Asia."

These extracts are sufficient to indicate the author's independence of thought on the untried military questions of the day, and it is evident from these that his essays are well worth careful perusal by military men.

The more important essays in this collection, besides the two quoted from, are The Wars of Frederick the Great, Seydlitz and the Prussian Cavalry, Marbot's Memoirs, The Prussian Cavalry in 1815, and Attack or Defense.

J.P.W.

The Campaign of Marengo, with Comments by Herbert H. Sargent, First Lieutenant, Second Cavalry. Chicago: A. C. McClurg and Company 1897. Pp. 240. $1.50.

The author of *Napoleon Bonaparte's First Campaign* here presents another of the great master's campaigns, in the same incisive language, and with the same understanding of the military plans and movements.

The military situation as it appeared to Bonaparte at the beginning of campaign is pointed out in an introductory chapter. The author evidently believes in the sincerity of the First Consul's desire for peace, but Sloan who has made a deeper study of the great schemer's character leaves little doubt that the letters to the governments of England and Austria were worded to give that impression to the French people, though in reality war been decided upon.

After an able discussion of the plans which Napoleon had under consider tion, the author proceeds:

"The main effort for supremacy between France and Austria should tak place in the valley of the Danube. There Austria should take the offensive there she should show her full strength; there she should make one mighty effort to decide her own or her adversary's fate. 'It is in the Valley of th Danube,' says the Archduke Charles, 'that the blows are to be struck which are decisive of the fate of France or Austria.'

"Austria did exactly the reverse of what she should have done. By taking the offensive in Italy, and by remaining on the defensive in Germany, she gave Bonaparte the opportunity to remain on the defensive in Italy and to take the offensive in Germany. She gave him the opportunity to carry out a plan of campaign which offered him the greatest results,—a plan which was perhaps, on the whole, one of the grandest strategic projects ever conceived by the mind of man."

Two more chapters are devoted to the military situation, one discussing Masséna's position at Genoa, the other Moreau's campaign in Germany. Then opens the campaign proper with the passage of the Alps and the battle of Marengo. The plans and movements on both sides are submitted to careful and searching analysis and are worthy of thorough study by all military men. Indeed, we know of no one hundred printed pages that contain so much valuable matter, or illustrations of so many of the principles of strategy: the influences of fortresses, the advantages of surprise and concealment, the effect of seizing an enemy's communications, and finally the necessity for violating the accepted principles of strategy when there is no other way to accomplish the desired result.

Even the violation of principles is made instructive. In the first place,

ıpoleon did the very thing he condemned Moreau for doing: invading a
ıntry with a double line of operations; but this was justified in this case by
: military situation. In no other way could he bring speedy relief to Mas-
ıa or stop the projected invasion of France in time. Again, his flank march
ım Ivrea to Milan, with but one line of retreat, and on that a fort still held
the Austrians, was a dangerous proceeding, but his skill in conducting this
ırch is a model for all who in future may be compelled to make one; more-
er, the possible result justified the risk, and it was part of his game of de-
ption of the enemy. Finally, in his anxiety to prevent the escape of the
emy, he failed to bring superior numbers to the point of contact, the battle-
ld, but he managed to bring superior numbers on the decisive point of the
ttle-field, so that tactically he carried out the principle, although strategically
had violated it.

"In this campaign Bonaparte was fortunate in having a Masséna at Genoa,
Suchet on the Var, and a Lannes at Montebello and at Marengo. He was
tunate, too, in having a Desaix near at hand, who dared march to the sound
the cannon, and who counselled hope when he might have counselled des-
ir."

The Emperor's last words as he was dying at St. Helena were these: "mon
. . . l'armée . . . Desaix." The three elements that so deeply influenced
career and life, and on which he built such high hopes. Yet how cruelly
Fates destroyed them all!

The little volume has the same dress as its predecessor, the maps are all
ıt is required and the typography is good.

J.P.W.

**e American Annual of Photography and Photographic Times Almanac
for 1898. Edited by Walter E. Woodbury, New York City. The
Scovill and Adams Co. Pp. 370. 300 Illustrations. Cloth, $1.25.**

The importance of photography as an aid in military affairs is being recog-
ed more fully every year, and the great improvements being made in it
ıtinually are rendering it still more important.

The invention of the dry plate, and later the film negative, have so simpli-
d photography and reduced the amount of apparatus necessary, that a
otographic outfit has become a necessary part of the equipment of an officer
reconnaisance duty. The next war will probably see a much greater use
the art than can now be predicted. Photography now has a place in the
rriculum of most of the schools for the post-graduate instruction of officers,
d many officers are ardently interested in the subject, not only in an ama-
ır way, but as a necessary adjunct to their professional acquirements.
all such we can commend the above book.

Even to a person not especially interested in photography, the fine illustra-
ns with which the volume is filled would be very attractive, but to the
otographer, the excellent examples of his craft and the well selected and
ıctical articles by eminent artists, would make it both interesting and in-
uctive.

t should be especially valuable to the amateur photographer, not alone on
:ount of the illustrations and the articles composing the text, but also for
well selected and reliable tables and formulae which compose the
pendix.

J.K.C.

Photographic Mosaics, for 1898, Edited by Edward L. Wilson. New York City. Published by Edward L. Wilson. Pp. 287. $1.00.

The well known reputation of the editor of "Photographic Mosaics" as a writer on photographic subjects, a skilled photographer, and an authority on all questions concerning the art, is a sufficient voucher for the quality of this work.

One of its valuable features is a thorough and critical review of the year's progress in photography with discussions of the different processes and of the novelties of the year.

The notes on photographic agents and processes are most useful and reliable, and the studies in posing and lighting, and in landscape work are very instructive. The illustrations include a collection of the best photographs of the year by artists of note.

It should be a valuable acquisition to professional photographers, as well as to others interested in photography.

J.K.C.

The Process Year Book for 1897. Vol. III. Conducted by Wm. Gamble; London: Penrose and Co. New York: G. Gennert. Pp. 127. $1.00.

Process work has a place in the military establishment in the reproduction of maps, plans, drawings, etc., and possibly in the reproduction of photographs. We therefore claim an interest in the above work in a professional way, and not alone on account of the beauty and variety of its illustrations. It is well worth possessing for the latter alone, however, for, as an example of the progress made in photo-mechanical reproduction it stands without a peer.

Only two or three of the illustrations are American. The illustrations may be taken as representative of the very best grade of English work. It is with some pride that we may say that fully as good work, if not better, of any of the different classes represented, may be done in this country; and, while the specimens of reproductions of pen and wash drawings may be first-class as reproductions, the drawings themselves do not compare with the average American work. It is doubtful if some of these drawings would be accepted by any but the inferior grade of publications in this country. They certainly would never be published as typical specimens of American work.

The color work and the half-tones of photographs are excellent, and the book as a whole is a fine collection of beautiful illustrations and interesting articles on process work.

J.K.C.

Bofors Mechanism for Quick-firing Guns. Stockholm, Sweden.

A phamphlet of about forty pages, with excellent illustrations, describing fully the Bofors mechanism and its action, in French, German and English.

Our Professional Notes contain a reprint of a portion of this phamphlet, hence no further comment is necessary here.

Bofors Naval Quick-firing Guns. Stockholm, Sweden.

A pamphlet of sixty pages describing, in three languages, the naval quick-firing guns with the Bofors breech-mechanism. The calibers are 1.46-inch, 1.85-inch, 2.24-inch, 2.56-inch, 2.76-inch, 2.95-inch, 3.94-inch, 4.72-inch, and 5.91-inch, each of lengths varying from 35 to 60 calibers. There are twelve excellent plates of illustrations.

A Hand-book on the Annexation of Hawaii by Lorrin A. Thurston. Pp. 83.

This small phamphlet presents the reasons why Hawaii should be annexed and answers the objections which have been advanced against this annexation, giving also a brief description of the people, laws, finances, educational system, resources and civilization of this interesting country.

The subject-matter is presented clearly, and substantiated by much documentary evidence and strong reasoning; the entire range of literature on the subject is here digested and concentrated for the information of the people, who must soon decide this important question.

Kriegstechnische Zeitschrift. A new Military Magazine, ten Numbers a Year. Berlin: E. S. Mittler und Sohn. Per Year, 10 M.

A new military magazine entitled *Kriegstechnische Zeitschrift* will begin with the new year, its purpose being to present and render available to officers of all arms the different ways in which science to-day comes to the aid of the art of war in all its branches, all the new discoveries, improvements and assistance which it affords to the military service. Science has acquired so much importance in the solution of the problems of the different arms of the service that it is necessary for the officer to become acquainted with its developments and progress. We need only call attention to the subjects of Electricity and Photography, to Ballooning and the Bicycle, to Mettallurgy, and to all the inventions through which science has improved even peace service and conduced so much to raise the fighting power of the army.—All such important and new means of improving the service are to be discussed in the *Zeitschrift*, and illustrated by appropriate diagrams so as to be directly useful to the corps of officers. The editorship has been undertaken by Colonel Hartmann, and the publishers are E. S. Mittler und Sohn. The *Kriegstechnische Zeitçchrift* will appear in ten numbers annually at ten Marks (about $2.50) per year, beginning in January, 1898; the first number will probably be issued in December, 1897.

Militärische Rundschau, a Monthly Journal of General Military Science, Edited by von Prollius. Leipsic, Germany.

The monthly journal published in Leipsic, entitled *Militärische Rundschau*, and edited by von Prollius, has enjoyed a wide circulation and an enviable reputation. It will be issued hereafter not in regular monthly numbers, but as occasion may require. The publishers believe that in this way they can best give attention to the important questions of the day and keep their readers properly informed. The price of each number will depend upon its size.

Die Umschau. A Journal of the Progress and Developments in the Domain of Science, Technology, Literature and Art. Yearly, 52 Numbers. Price per Quarter, 2.50 Marks. Frankfort-on-the-Main, Neue Kräne 19/21.

No. 42 of this publication contains the following articles:

The Significance of the Trans-Siberian Railway in the World's Commerce, by Dr. F. Lampe.

Arnold Böcklin and His Works, by Dr. E. Braun.

The Historico-Philosophic System of the Present Time by Karl Lory.

The lectures delivered before the Natural History Association meeting in Brunswick.

Also a number of minor articles.

La Prensa Militar, Buenos Aires, Calle Reconquista 2034, Imprenta, Redaccion y Administracion, receives communications and information for publication in all languages.

Gratefully receives consignments and exchanges.

BOOK NOTICES.

[These books will be fully *reviewed* as space becomes available.]

Forty-six Years in the Army, by Lieutenant-General John M. Schofield. New York: The Century Co. 1897. Pp. 577.

Descriptive General Chemistry. A Text Book for a Short Course. By S. E. Tillman, Professor of Chemistry, Minerology and Geology, United States Military Academy. West Point, N. Y.: United States Military Academy Press. 1897. Pp. 367.

General Robert Edward Lee, Soldier, Citizen, and Christian Patriot. Edited by R. A. Brock, Secretary Southern Historical Society. Richmond, Va., Royal Publishing Co., 1897. Pp. 586.

The International Annual of Anthony's Bulletin and American Process Year-Book. 1898. Edited by W. I. Scandlin. New York: E. and H. T. Anthony & Co., 591 Broadway. Pp. 303.

INDEX TO CURRENT ARTILLERY LITERATURE.

PERIODICALS CITED.

Abbreviations employed in index are added here in brackets.

All the periodicals are preserved in the Artillery School Library, Fort Monroe, Virginia.

ENGLAND.

Aldershot Military Society. *Occasional.*
Aldershot. Copies 6d each.

Arms and Explosives. [*Arms and Ex.*] *Monthly.*
Effingham House, Arundel Street, Strand, London, W.C. Per year 7s.

Army and Navy Gazette. [*A. and N. Gaz.*] *Weekly.*
3 *York Street, Covent Garden, London. Per year £1 12s 6d.*

Canadian Military Gazette. [*Can. Gaz.*] *Fortnightly.*
Box 2179 Montreal, Canada. Per year $2.00.

The Engineer. [*Eng.*] *Weekly.*
33 *Norfolk Street, Strand, London. Per year £2 6d.*

Engineering. [*Eng'ing.*] *Weekly.*
35-36 *Bedford Street, Strand, London, W.C. Per year £2 6d.*

Journal of the Royal United Service Institution. [*Jour. R.U.S.I.*] *Monthly.*
17 *Great George Street, London, S.W. Per year 24 s.*

Journal of the United Service Institution of India. [*Jour. U. S. I. India*] *Monthly.*
Simla, India. Per year $2.50.

Photographic Journal. [*Photo. Jour.*] *Monthly.*
12 *Hanover Square, London.*

Proceedings of the Institution of Civil Engineers. [*Proceedings I. C. E.*]
25 *Great George Street, Westminister, London.*

Proceedings of the Institution of Mechanical Engineers.
[*Proceedings I. M. E.*] 19 *Victoria Street, Westminister, London.*

Proceedings of the Royal Artillery Institution. [*Proceedings R. A. I.*] *Monthly.*
Woolwich, England.

Professional Papers of the Corps of Royal Engineers.
[*Prof. Papers Corps Royal Eng'rs.*]
Chatham, England.

Review of Reviews. [*Rev. of Rev. Austral.*] *Monthly.*
169 *Queen Street, Melbourne, Australia. Per year* 11 s. 6 d.

Transactions of the Canadian Institute. [*Trans. Canadian Inst.*]
58 *Richmond Street, Toronto, Canada.*

Transactions of the Canadian Society of Civil Engineers.
[*Trans. Canadian Soc. C. E.*]
Montreal, Canada.

Transactions of the East of Scotland Tactical Society.
[*Trans. E. of S. Tactical Soc.*]
51 *Hanover Street, Edinburgh, Scotland.*

Transactions of the Institute of Naval Architects.
[*Trans. Inst. Naval Architects.*]
5 *Adelphi Terrace, London, W.C.*

United Service Gazette. [*U. S. Gaz.*] *Weekly.*
4-6 *Catherine Street, Strand, London, W. C. Per year* £1 10*s* 6*d.*

FRANCE.

L'Avenir Militaire. [*Avenir.*] *Semi-weekly.*
13 *Quai Voltaire, Paris. Per year* 18 *Fr.*

Le Génie Civil. [*Génie C.*] *Weekly.*
6 *Rue de la Chaussée d'Antin, Paris. Per year* 45 *Fr.*

Journal des Sciences Militaires. [*Sciences Militaires.*] *Monthly.*
Rue et Passage Dauphine 30, *Paris. Per year* 40 *Fr.*

La Marine Française. [*Marine F.*] *Semi-monthly.*
23 *Rue Madame, Paris. Per year* 30 *Fr.*

Mémoires et Compte Rendu des Travaux de la Société des Ingénieurs Civils.
[*Ingénieurs Civils.*] *Monthly.*
10 *Cité Rougemont, Paris. Per year* 36 *Fr.*

Mémorial des Poudres et Salpêtres. [*M. Poudres et S.*] *Quarterly.*
Quai des Grands-Augustins, 55, *Paris. Per year* 12 *Fr.*

Le Monde Militaire. [*Monde.*] *Fortnightly.*
76 *Rue de Seine, Paris. Per year* 6 *Fr.*

Revue d'Artillerie. [*R. Artillerie.*] *Monthly.*
5 *Rue des Beaux-Arts, Paris. Per year* 22 *Fr.*

Revue de Cavalerie. [*R. Cav.*] *Monthly.*
Berger Levrault et Cie, Rue des Beaux-Arts 5, *Paris. Per year* 33 *Fr.*

Revue du Cercle Militaire. [*Cercle.*] *Weekly.*
37 *Rue de Bellechasse, Paris. Per year* 27 *Fr.*

Revue du Génie Militaire. [*Génie M.*] *Monthly.*
8 *Rue Saint-Dominique, Paris. Per year* 27 *Fr.*

Revue d'Infanterie. [*R. Inf.*] *Monthly.*
11 *Place Saint André-des-Arts, Paris. Per year* 25 *Fr.*

Revue Maritime. [*R. Maritime.*] *Monthly.*
L. Baudoin, Rue et Passage Dauphine 30, *Paris. Per year* 56 *Fr.*

Revue Militaire de l'Etranger. [*Etranger.*] *Monthly.*
L. Baudoin, Rue et Passage Dauphine 30, *Paris. Per year* 15 *Fr.*

Revue Militaire Universelle. [*R. Univ.*] *Monthly.*
11 *Place Saint André-des-Arts, Paris. Per year* 25 *Fr.*

Le Yacht—Journal de la Marine. [*Yacht.*] *Weekly.*
55 *Rue de Chateaudun, Paris. Per year* 30 *Fr.*

GERMANY.

Allgemeine Militaer-Zeitung. [*A. M.-Zeitung.*] *Semi-weekly.*
Darmstadt. Per year 24 *M.*

Archiv fuer die Artillerie-und Ingenieur Offiziere. [*Archiv.*] *Monthly.*
Koch Strasse, 68-78, *Berlin*, *S. W.* 12. *Per year* 12 *M.*

Beiheft zum Militaer-Wochenblatt. [*Beiheft.*]
Koch Strasse, 68, *S. W.*, *Berlin.*

Deutsche Heeres-Zeitung. [*Heeres-Zeit.*] *Semi-weekly.*
Wilhelmstrasse 15, *Berlin. Per year* $6.00.

Internationale Revue. [*Int. Revue.*] *Monthly.*
Blasewitzer Strasse 15, *Dresden. Per quarter* 6 *M.*

Jahrbuecher fuer die deutsche Armee und Marine. [*Jahrbuecher.*] *Monthly.*
Mohren Strasse, 19, *Berlin*, *W.* 8. *Per year* 32 *M.*

Kriegstechnische Zeitschrift. [*Kriegstech.*] *Ten numbers a year.*
Koch Strasse, 68-71, *Berlin. Per year* 10 *M.*

Kriegswaffen. [*Kriegswaffen.*] *Monthly.*
Rathenow, *Germany. Per year* $4.50.

Marine Rundschau. [*Mar. Rundschau.*] *Monthly.*
Koch Strasse, 68-70, *Berlin. Per year* 3 *M.*

Militaer-Wochenblatt. [*Wochenblatt.*] *Fortnightly.*
Koch Strasse, 68, *Berlin*, *S. W.* 12. *Per Year* 20 *M.*

Militärische Rundschau. [*Mil. Rundschau.*] *Occasional.*
Zuckschwerdt & Co., *Leipzig. Per quarter* 4.75 *M.*

Stahl und Eisen. [*Stahl u. Eisen.*] *Fortnightly.*
Schadenplatz 14, *Düsseldorf. Per year* $5.00.

Umschau, Die. [*Umschau.*] *Weekly.*
Frankfort a. M. Per year 10 *M.*

AUSTRIA.

Mittheilungen ueber Gegenstaende des Artillerie und Genie-Wesens.
[*Mitth. Art. u. G.*] *Monthly.*
Wien, *VI*, *Getreidemarkt* 9. *Per year* 1 *Fl.* 50 *Kr.*

Mittheilungen aus dem Gebiete des Seewesens. [*Seewesens.*] *Monthly.*
Pola. Per year 14 *M.*

Organ der Militaer Wissenchaftlichen Vereine. [*Vereine.*]
Wien I, *Stauchgasse No.* 4. *Per year*, 8-14 *numbers*, 6 *Fl.*

Zeitschrift des Oesterreichischen Ingenieur und Architekten Vereines.
[*Z. Architekten Vereines.*] *Weekly.*
I. Eschenbachgasse, *No.* 9, *Wien. Per year* 10 *Fl.*

SWITZERLAND AND BELGIUM.

Allgemeine Schweizerische Militaer-Zeitung. [*A.S.M. Zeitung.*] *Weekly.*
Basel, *Switzerland. Per year*, 8 *Fr.*

La Belgique Militaire. [*Belgique M.*] *Weekly.*
Rue St. Georges 32, *Ixelles*, *Belgium. Per year* 12.50 *Fr.*

Monatschrift fuer Offiziere Aller Waffen. [*Monatschr.*] *Monthly.*
Frauenfeld, *Switzerland. Per year* 5 *Fr.*, *plus postage.*

Revue de l'Armée Belge. [*A. Belge.*] *Bi-monthly.*
22 *Rue des Guillemins*, *Liège*, *Belgium. Per year* 13 *Fr.*

Revue Militaire Suisse. [*R. M. Suisse.*] *Monthly.*
Escalier-du-Marché, *Lausanne*, *Switzerland. Per year* 10 *Fr.*

Schweizerische Zeitschrift fuer Artillerie und Genie. [*S. Zeitschrift.*]
Monthly.
Frauenfeld, Switzerland. Per year 8 *Fr.* 20 *centimes.*

SPAIN, PORTUGAL AND SOUTH AMERICA.

Boletin del Centro Naval. [*Boletin.*] *Monthly.*
438 *Alsina, Buenos Aires, Argentina Republica. Per year* $11.00.

Circulo Naval,—Revista de Marina. [*R. de Marina.*] *Monthly.*
Casilla num. 852, *Valparaiso, Chili.*

Memorial de Artilleria. [*M. de Art.*] *Monthly.*
Farmacia, num. 13, *Madrid, Spain. Per year, U. S.,* $3.40.

El Porvenir Militar. [*Porvenir.*] *Weekly.*
258 *Calle Montevideo, Buenos Aires, Argentina. Per year* 10 $\$\frac{m}{n}$.

La Prensa Militar. [*Prensa.*] *Weekly.*
Reconquista 1034, *Buenos Aires, Argentina.*

Revista Cientifico-Militar. [*Cientifico M.*] *Semi-monthly.*
5 *Calle de Cervantes, Barcelona, Spain. Per year* 32 *Fr.*

Revista da Commissao Technica Militar Consultiva. [*R. da Commissao.*]
Bi-monthly. Praça da Republica N. 32, *Rio de Janeiro, Brasil.*

Revista de Engenheria Militar. [*Engenheria Mil.*] *Monthly.*
Quartel da Cruz dos Quatro Caminhos, Lisbon, Portugal. Per year 1 $ 800 *réis.*

Revista do Exercito e da Armada. [*Exercito.*] *Monthly.*
Largo de S. Domingos No. 11, *Lisbon, Portugal. Per year U. S.* $6.00.

Revista General de Marina, [*R. G. de Marina.*] *Monthly.*
56 *Calle de Alcalá, Madrid, Spain. Price U. S.* $4.45.

Revista Maritima Brazileira. [*R.M. Brazil.*] *Bi-monthly.*
Rue do Conseheiro Saraiva n. 12, *Rio de Janeiro, Brazil. Per year* $10.00.

Revista Militar. [*R. Mil. Portugal.*] *Semi-monthly.*
262 *Rua da Princeza, Lisbon, Portugal. Per year,* $2.60.

Revista Militar. [*R. Mil. Chile.*] *Monthly.*
Santiago, Chili.

HOLLAND AND SCANDINAVIA.

Artillerie-Tidskrift. [*Art. Tids.*] *Bi-monthly.*
Stockholm, Sweden. Per year, U. S., $1.75.

De Militaert Gids. [*M. Gids.*] *Bi-monthly.*
De Erven F. Bohn, Haarlem, Holland. Per year, U. S., $2.00.

Militaert Tidsskrift. [*M. Tids.*] *Bi-monthly.*
Copenhagen, Denmark. Per year, U. S., $2.50.

Norsk Militeert Tidsskrift. [*N. M. Tids.*] *Monthly.*
Christiania, Norway. Per year, U. S., $2.50.

RUSSIA.

Artilleriiskii Journal. [*Art. Journal.*] *Monthly.*
Furschtatskaia Ulitza, St. Petersburg, Russia.

Razviedchik. [*Razv.*]
KoloKolwaia Ulitza, No. 14, *St Petersburg, Russia.*

Russkii Invalide. [*Invalide.*]
Wadizdinskia Ulitza, No. 48, *St. Petersburg, Russia.*

ITALY.

Rivista di Artiglieria é Genio. [*R. Artig.*] *Monthly.*
Tipografia Voghera Enrico, Rome. Per year 30 *L.*

Rivista Marittima. [*R. Maritt.*] *Monthly.*
Rome. Per year 25 *L.*

UNITED STATES.

American Engineer and Railroad Journal. [*Eng. and Rail. Jour.*] *Monthly.*
47 *Cedar Street, New York City. Per year* $3.00.

American Journal of Mathematics. [*Jour. Math.*]
John Hopkins University, Baltimore, Md.

American Machinist. [*Amer. Mach.*] *Weekly.*
256 *Broadway, New York City. Per year* $3.00.

American Manufacturer and Iron World. [*Man. and Iron World.*] *Weekly.*
59 *Ninth Street, Pittsburgh, Pa. Per year* $4.00.

Annual of the Office of Naval Intelligence. [*Naval Intelligence.*]
Washington, D. C.

Army and Navy Journal. [*A. and N. J.*] *Weekly.*
New York City. Per year $6.00.

Army and Navy Register. [*A. and N. R.*] *Weekly.*
Washington, D. C. Per year $3.00.

Bulletin of the American Mathematical Society. [*Bulletin Math. Soc.*]
University Heights, New York City.

Cassier's Magazine. [*Cas. Mag.*] *Monthly.*
World Building, New York City. Per year $3.00.

Digest of Physical Tests. [*Digest.*] *Quarterly.*
1424 *N. 9th Street, Philadelphia. Per year* $1.00.

Electrical Engineer. [*Elec. Eng.*] *Weekly.*
203 *Broadway, New York City. Per year* $3.00.

Electrical Engineering. [*Elec. Eng'ing.*] *Semi-Monthly.*
443 *The Rookery, Chicago, Ill. Per year* $1.00.

Electrical Review. [*Elec. Rev. N. Y.*] *Weekly.*
13 *Park Row, New York City. Per Year* $3.00.

The Engineer. [*Eng. N. Y.*] *Fortnightly.*
106-108 *Fulton Street, New York City. Per year* $2.50.

Engineering Magazine.]*Eng'ing. Mag.*] *Monthly.*
120-122 *Liberty Street, New York City. Per year* $3.00.

Engineering News and American Railroad Journal.
[*Eng'ing News and R.R. Jour.*] *Weekly.*
Tribune Building, New York City. Per year $5.00.

Engineering and Mining Journal. [*Eng. and Min. Jour.*] *Weekly.*
253 *Broadway, New York City. Per year* $5.00.

The Iron Age. [*Iron Age.*] *Weekly.*
96-102 *Reade Street, New York City. Per year* $4.50.

Journal of Electricity. [*Jour. Elec.*] *Monthly.*
421 *Market Street, San Francisco, Cal.*

Journal of the American Chemical Society. [*J. Chem. S.*] *Monthly.*
Easton, Pa. Per year $5.00.

Journal American Society of Naval Engineers. [*A.S.N. Egrs.*] *Quarterly.*
Navy Department, Washington, D. C.

Journal of the Association of Engineering Societies. [*Eng. Soc.*] *Monthly*
257 *South Fourth Street, Philadelphia. Per year* $3.00.

Journal of the Franklin Institute. [*Frank. Inst.*] *Monthly.*
Philadelphia, Pa., Per year $5.00.

Journal of the Military Service Institution. [*Jour. M. S. I,*] *Bi-monthly.*
Governor's Island, New York City. Per year $4.00.

Journal of the U.S. Cavalry Association. [*Jour. U. S. Cavalry*] *Quarterly.*
Fort Leavenworth, Kansas.

Journal of the Western Society of Engineers. [*W. Soc. Eng.*] *Bi-monthly.*
1737 *Monadnock Block, Chicago, Illinois. Per year* $2.00.

Marine Review. [*Mar. Rev.*] *Weekly.*
Cleveland, Ohio. Per year $2.00.

Military Information Division. [*Mil. Information Div.*] *Occasional.*
War Department, Washington, D. C.

Notes on Naval Progress. [*Naval Intelligence.*] *Occasional.*
Navy Department, Washington, D. C.

Pennsylvania Magazine of History and Biography. [*Penn. Mag. of Hist.*] *Quarterly.*
13 *Locust Street, Philadelphia. Per year* $3.00.

The Photographic Times. [*Phot. Times.*] *Weekly.*
60 *and* 62 *E.* 11*th Street, New York City. Per year* $5.00.

Physical Review. [*Phys. Rev.*] *Bi-monthly.*
Cornell University, Ithaca, New York. Per year $3.00.

Popular Science Monthly. [*Pop. Sc. Mo.*] *Monthly.*
72 *Fifth Avenue, New York City. Per year* $5.00.

Proceedings of the American Philosophical Society.
[*Proceedings of A. Phil. Soc.*]
104 *South Fifth Street, Philadelphia, Pa.*

Proceedings of the U. S. Naval Institute. [*Naval Inst.*] *Quarterly.*
Annapolis, Md. Per year $3.50.

Public Opinion. [*Pub. Opin.*] *Weekly.*
New York City. Per year $2.50.

Review of Reviews. *Monthly.*
13 *Astor Place, New York City. Per year* $2.50.

The Scientific American. [*Scien. Amer.*] *Weekly.*
361 *Broadway, New York City. Per year* $3.00.

Shooting and Fishing. *Weekly.*
293 *Broadway, New York City. Per year* $3.50.

Technology Quarterly. [*Tech. Quart.*] *Quarterly.*
Mass. Inst. of Tech., Boston, Mass. Per year, $3.00.

Transactions American Institute of Electrical Engineers.
[*Inst. Elec. Eng'rs.*] *Monthly.*
26 *Cortlandt Street, New York City. Per year* $5.00.

Transactions American Institute of Mining Engineers.
[*Trans. Inst. Min. Eng'rs.*]
P. O. Box 225, *New York City.*

Transactions of the American Society of Civil Engineers.
[*Proceedings A.S. Civil Eng'rs*]
127 *East* 23*d Street, New York City.*

Transactions of the American Society of Mechanical Engineers.
[*Trans. A. S. Mech. Eng'rs.*]
12 *West* 31*st Street, New York City.*

Transactions of the Society of Naval Architects and Marine Engineers.
[*Naval Architects and Marine Eng'rs.*]
12 *West* 31*st Street, New York City.*

Western Electrician. [*West. Elec.*] *Weekly.*
510 *Marquette Building, Chicago, Illinois. Per year* $3.00.

Wilson's Photographic Magazine. [*Phot. Mag.*] *Monthly.*
853 *Broadway, New York City. Per year* $3.00.

ORGANIZATION AND ADMINISTRATION.

Report of the Secretary of War, U. S.—A. and N. Jour., November 27.

Annual report of Major General Commanding.—A. and N. Reg., October 23.

The weakness of modern armies.—Pub. Opin., September 16.

The relative advantages and disadvantages of voluntary and compulsory service, both from a military and national point of view.—**Jour. R. U. S. I.**, August, September, October.

A study of the organization of military colonies.—**Exercito**, September.

The sub-units of the infantry company.—**Exercito**, September.

Good words for the artillery. (Reports of Major-General Wesley Merritt and Colonel John I. Rodgers).—**A. and N. Jour.**, October 30.

Increase in the artillery. (General Wingate).—**Jour. M. S. I.**, November.

Notes on artillery, dictated by Napoleon at St. Helena.—**R. Artillerie**, June.

German opinions on various questions relative to the constitution of R. F. Artillery.—**R. Artillerie**, September.

The question of the organization of field batteries armed with R. F. guns.—**Wochenblatt**, October 16.

High-angle pieces for field artillery.—**Jaerbücher**, October.

The fighting unit in coast defense.—**Jour. M. S. I.**, November.

Increase in foot artillery (France).—**Wochenblatt**, September 11.

Fusion of the artillery and engineers (France).—**Int. Revue**, September.

Railroad troops (Austria).—**Cientifico M.**, September 15.

Military organization of our railroads (France).—**Avenir**, October 1.

Official report of 25th Infantry bicycle corps.—**A. and N. Reg.**, September 25.

The 25th Infantry bicycle corps.—**A. and N. Jour.**, October 2.

Organization of bicyclist service (Italy).—**Etranger**, September.

Field strength of cyclists for corps, divisions, etc. (Italy).—**Wochenblatt**, September 1.

Military cyclists.—**Int. Revue**, October.

A modern signal corps.—**Jour. M. S. I.**, November.

The formation of an adequate reserve of trained seamen.—**Jour. R. U. S. I.**, October.

Proposed recruitment (conscription) and organization of the Argentine army.—**Porvenir**, September 16, 24.

Creation of an VIII army corps district (Spain).—**Etranger**, September.

The Indian army.—**Pub. Opin.**, September 30.

The army in India.—**A. and N. Gaz.**, August 21.

The best method of recruiting the Indian armies.—**Jour. U. S. I., India**, July.

The defensive forces of New South Wales.—**U. S. Gaz.**, September 25.

The Canadian militia.—**Can. Gaz.**, October 20.

The reorganization of the Italian army.—**Etranger**, September; **Cercle**, August 28.

The army organization law in Italy.—**Heeres-Zeit.**, September 29, October 6, 9, 13.

The German army.—**A. and N. Gaz.**, October 16.

Changes in the Russian army.—**Heeres-Zeit.**, August 7.

The military force of Guinea.—**R. Mil. Portugal**, August 15.

The *esprit* of the Japanese army.—**A. S. M. Zeit.**, October 2.

TACTICS.

Battle tactics.—**Cercle**, October 16.

The battle.—**Cercle**, September 25, October 2, 9.

The fire-tactics of infantry since 1793.—**Monatschr**, August, September; **R. M. Suisse**, September 15.

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CORRIGENDA.

Page 273. The last equation should be:

$$\frac{y}{x} < \frac{1}{4}.$$

Page 274. Second line should read:

$$\frac{y}{x} > \frac{1}{4}.$$

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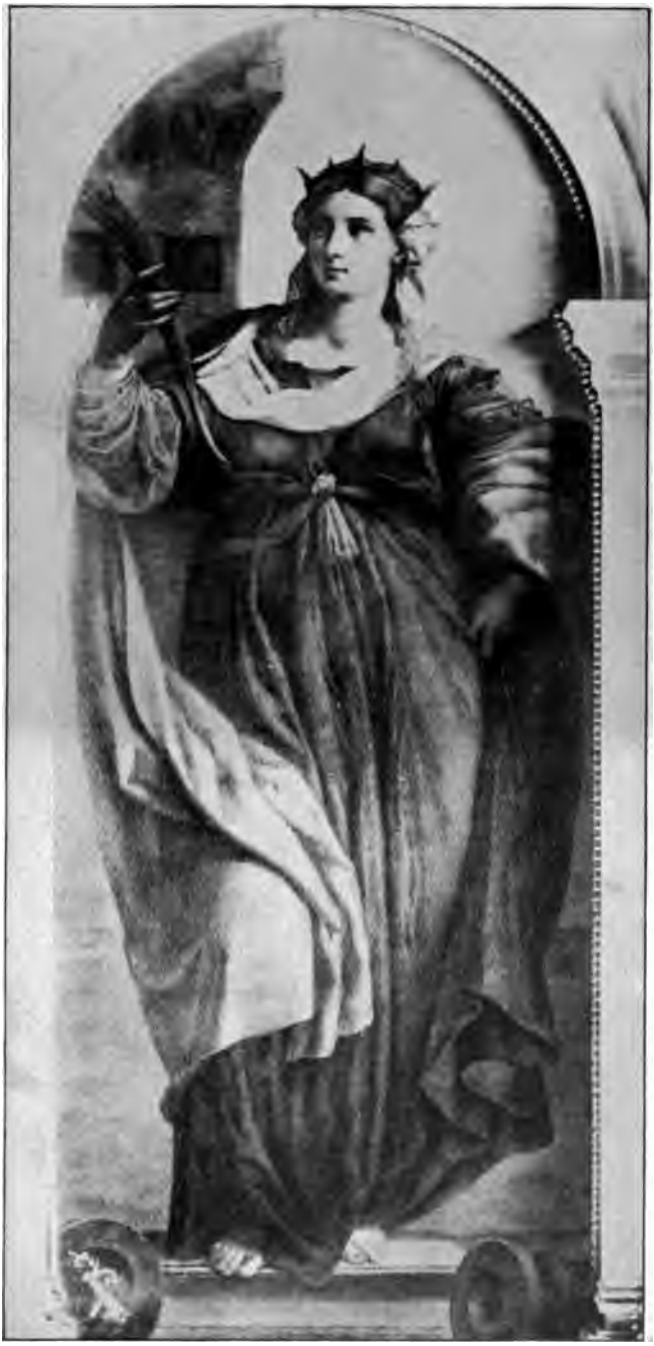

PALMA V. STA. BARBARA. **VENEZIA.**

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NFEDERATE ORDNANCE DURING THE WAR.

**Le Roy Brown, President Alabama Polytechnic Institute, Auburn.
Formerly Lieutenant-Colonel of Ordnance of the Confederate
Army, Commanding the Richmond Arsenal.**

complying with your request to write an article for your
***nal* giving experiences and difficulties in obtaining ordnance**
ng the war, I will endeavor relying on my memory and some
lable memoranda preserved, to give you a statement of the
ction and manufacture of ordnance stores for the use of the
ederate armies, so far as such manufacture was under my
rvation and control. After a year's service in the field as an
lery officer, I was ordered to Richmond and made Superin-
lent of Armories, with the rank of Major in the regular
y, a new office in the C. S. army, and sent to various points
North Carolina and Georgia, to inspect and report on the
ities possessed by different manufactories for making arms,
ds, sulphuric acid, etc.

s a general rule the facilities for manufacturing were meagre
crude, giving little prospect for an early serviceable product.
arly in the spring of 1862 I was ordered to report at Holly
ngs, Mississippi, and take charge of a factory just purchased
he Confederacy, and designed for the manufacture of small
s. It was not many months before the defeat of the Con-
rate army under General Albert Sydney Johnston, at Shiloh,
n., caused a hurried removal of all the machinery to Meri-
, Miss. Having reported to the chief of ordnance at Rich-
d, Va., I was assigned to duty connected with the ordnance
rtment.

he Confederate Congress had authorized the appointment of
new ordnance officers, and the applications to the war depart-
t became so numerous and persistent for these appointments,

that the Secretary of War, Colonel Randolph, ordered that all applicants should submit to an examination, and that appointments would be made in order of merit, as reported by the board of examiners. Thus what we are now familiar with as Civil Service examinations, were introduced by the Confederate War Department in 1862, in the appointment of ordnance officers.

I was made Lieutenant-Colonel of Ordnance, and as President of the Board, with two other officers, constituted the board of examiners. By direction of General J. Gorgas, the Chief of Ordnance, I prepared a Field Ordnance Manual by abridging the old United States Manual and adapting it to our service when necessary. This was published and distributed in the army.

The examination embraced the field ordnance manual as contained in this abridged edition, the elements of algebra, chemistry, and physics, with some knowledge of trigonometry. The first examinations were held in Richmond. Of course the fact of the examinations greatly diminished the number of applicants. Of those recommended by the board, so many were from Virginia that the President declined to appoint them until an equal opportunity was given to the young men of the different armies of the Confederacy in other states.

Hence I was directed to report to and conduct examinations in the armies of Generals Lee and Jackson in Virginia, General Bragg in Tennessee, and General Pemberton in Mississippi. Under other officers examinations were conducted in Alabama and Florida.

The result of this sifting process was that the army was supplied with capable and efficient ordnance officers.

Early in 1863 I was appointed Commandant of the Richmond Arsenal. Here the greater part ot the ordnance and ordnance stores were prepared for the use of the Confederate armies.

The Arsenal occupied a number of large tobacco factories at the foot of Seventh street near the Tredegar iron works between Cary street and James river. It included all the machine shops for working wood and iron organized into different departments, each under subordinate officers, arranged to manufacture ordnance stores for the use of the Confederate army.

Cannon were made at the Tredegar iron works, including siege and field guns, Napoleons, howitzers, and banded cast-iron guns. Steel guns were not made. We had no facilities for making steel, and no time to experiment.

The steel guns used by the Confederates were highly valued, and with the exception of a few purchased abroad were all captured from the Federals.

At the beginning of the war the machinery belonging to the armory at Harpers Ferry was removed to Richmond, and there established. This armory manufactured Enfield rifles, and the product was very small, not exceeding five hundred per month.

With the exception of a few thousand rifles, the soldiers at the beginning of the war were armed with the old smooth-bore muskets, and with old Austrian and Belgian rifles imported. These they exchanged for Enfield rifles as they were favored by the fortunes of war.

In the summer of 1862, after the seven days battles around Richmond between General Lee and General McClellan, men were detailed to collect arms from the field, which were carried to the Richmond Arsenal. And then as quickly as possible repaired and reissued to the army. Subsequently through the blockade runners a large importation of excellent rifles was received and distributed.

When the men detailed for this purpose were collecting the thousands of Enfield rifles left by the Federals on the battle ields around Richmond, I remember seeing a few steel breast plates that had been worn by the Federal soldiers who were killed n battle. They were solid steel in two parts, shaped to fit the chest, and were worn under the coat. These were brought as curiosities to the Arsenal, and had been pierced by bullets. I remember this as a fact of my own knowledge. Some years ago he charge that some of the Federal soldiers wore breast-plates was denied and decried as a gross slander, and in reply thereto published in the *Nation* the statement here made. These no doubt represented a few sporadic cases, worn without the knowledge of others. The Confederate soldiers had to rely for mproved arms on captures on the battlefield, and on importation, when the blockade could be avoided, having available no large armory.

The Tredegar iron works at Richmond, Virginia, was the chief manufactory of seige and field guns, all cast iron and smooth bore. The large Columbiads were made there, also the howitzers, 2-inch bronze Napoleons, etc. But the highly valued banded Parrot 3-inch rifles, with which the army was well supplied, were, as a rule, captured on the battlefield.

As the war continued great difficulties were experienced in obtaining the needful ordnance supplies, and many devices were resorted to. After the battles about Chattanooga, Tennessee, when the Confederacy lost possession of the copper mines, no more bronze Napoleons could be made.; but instead thereof, a light cast-iron 12-pounder, well banded after the manner of the Parrot guns, was made, and found to be equally as effective as the Napoleon.

At the beginning of the war it must be remembered the Confederacy had no improved arms, no powder mills, no arsenals, no armories, no cap machines, and no improved cannon. All supplies, at first, were obtained by importation, though the blockade subsequently cut off this foreign supply. All arms were percussion-cap muzzle loaders. In the beginning the old flint-lock smooth-bore muskets were changed to percussion-cap lock, and issued to the troops.

To keep a supply of percussion caps was a difficult and very serious problem, as the demand for caps was about twice as great as it was for cartridges.

The machines made after the United States pattern did not yield a large supply, and simpler and much more efficient machines for making fitting, pressing, and varnishing caps were invented and made by southern mechanics.

After the Federals obtained possession of the copper mines of Tennessee great anxiety was excited as to the future store of copper, from which to manufacture percussion caps.

The casting of bronze field guns was immediately suspended and all available copper was carefully hoarded for the manufacture of caps. It soon became apparent that the supply would be exhausted and the armies rendered useless unless other sources of supply could be obtained. No reliance could be placed on the supply from abroad, though large orders were forwarded, so stringent was the blockade; of course the knowledge of this scarcity of copper was not made public.

In this emergency, it was concluded to render available if possible, some of the copper turpentine and apple-brandy stills which still existed in North Carolina in large numbers.

Secretly, with the approval of the Chief of Ordnance, an officer was dispatched, with the necessary authority to purchase or impress all copper stills found available, and ship the same, cut into strips, to the Richmond Arsenal. By extraordinary energy he was enabled to forward the amount necessary for our use. The strips of copper of these old stills were rerolled and handed over to the cap manufacturer. And thus were all the caps issued from the arsenal and used by the armies of the Confederate tes, during the last twelve months of the war, manufactured om the copper stills of North Carolina.

After the completion of the cap machines, which were an im- ovement on the old United States machine, eight hands only, o being men, the others boys and girls, frequently manufac- red from the strip copper over three hundred thousand caps, thin eight hours, stamping, filling, preparing and varnishing em.

These cap machines thus had a capacity of producing a million day.

These caps made at the arsenal were frequently tested, and ronounced to be superior in resisting effects of moisture and in eneral efficiency.

For the completion of these machines, the Confederate govern- ent awarded the inventor, an employée of the arsenal, the sum one hundred and twenty-five thousand dollars, being then qual to two thousand in gold.

To manufacture the fulminate of mercury we needed nitric cid and mercury.

A quantity of mercury was obtained early in the war from lexico. To make nitric acid we required nitre and sulphuric cid. The sulphuric acid we manufactured in North Carolina, fter many failures and difficulties, especially in obtaining the ead to line the chambers.

Nitre was made by the Nitre and Mining Bureau, especially rganized for that purpose. Everywhere about the environs of ichmond could be seen large earthen ricks and heaps which ontained dead horses and other animals, designed for use in the nanufacture of nitre. The available earth from caves was also nade to yield its quota of nitre. With this sulphuric acid and itre, on the banks of the James river, we manufactured the nitric cid required in the manufacture of fulminate.

Near the close of the war the supply of mercury became xhausted. Here was a most serious difficulty; we had not and ould not obtain the mercury, an essential material with which to nanufacture fulminate of mercury, and without caps the army ould not fight, and must be disbanded. This was an extremely erious situation, as no mercury could be obtained in the [illegible] f the Confederacy. We began to experiment on a substitute, nd fortunately found [illegible] chlorate of otash and sulphuret of antimony, [illegible] properly com- ined answered the purpose as a substitute [illegible] round Petersburg during [illegible] fought with caps filled with this novel substitute. Our lead was obtained chiefly, and in the last years of the war, entirely from the lead mined near Wytheville, Virginia.

The mines were worked night and day, and the lead converted into bullets as fast as received.

The old regulation shrapnel shells were filled with leaden balls and sulphur. The Confederacy had neither lead nor sulphur to spare, and used instead small iron balls, and filled with asphalt.

We had no private manufactories established which could furnish the appliances needed, and frequently everything had to be done from the very beginning, by the ordnance department, and the army in the field. For instance, to run the forges to make the irons for the artillery carriages we needed charcoal. To obtain this I purchased the timber of a number of acres of woodland on the south side of the James river, and secured a detail of men to burn the charcoal for the use of our forge department.

During the winter men from General Lee's army cut the timber and shipped it to Richmond, with which artillery carriage were made on which to mount the guns to fight the battles i the spring. Men appointed for that purpose followed the arm and collected the hides of the slaughtered animals that were use to cover the saddle-trees made of timber, cut by tempora details of men from the army in the field.

As the war continued efforts were made to build perman and well appointed arsenals, as at Macon and Augusta, Georg

The large arsenal at Augusta, under the management Colonel Rains was especially devoted to the manufacture powder. Toward the close of the war it was making an abun ant supply of very superior character, equal, and in so respects, superior to that imported from foreign countries.

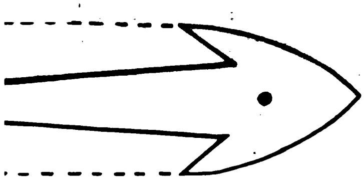
Under the demands of necessity in many instances, cot converted into rubber cloth was used in the manufacture infantry accoutrements, and was found especially useful in ma ing belts for machinery. Models of inventions were frequent sent to the arsenal, of which large numbers were valueless, a those good in theory could not be tried for want of skilled n chinists and ordnance supplies. I remember on one occasio the last year of the war, that a large number of Spencer breec loading rifles, the result of a capture, were turned over to th arsenal, and though greatly desired by the troops, could not b reissued for want of ammunition. In the effort to make th cartridges for the Spencer rifles, in the first place tools had t

, wi to make the tools used for making the
H e surrender of Richmond came before the
t es re
pr at t a l to i ease t y
ige th ai mo
b in p of the C .
T p pr ed w t oreti ly cor rth men,
i s y la tl r iden plan was
to from C as t ft of great

Tl sent by him to the war department, and hence found
to the arsenal, where the drawings were regarded with
since they corresponded exactly with those made at the
al years previously.

T was to fire an elongated compound projectile made of
d hard wood, or papier maché.

t diagram the heavy lines represent a section of the
row bullet, with center of gravity well forward, the dot-
represent the hollow sabot of wood, or hard papier



On firing, the lighter material, moving first, would press outwards the arrow head, and thus destroy windage, and the flight of the trajectory would be as an arrow, with-ut rotating on the shorter axis, inasmuch as the center of iner-ia of the projectile would be in advance of the center of resis-ance of the air. At least that was the theory of the compound rojectile, devised for the old smooth-bore musket.

An attempt was made to use on the field round concussion shell rom the howitzers as mortars. In this concussion shell a fric-ion primer properly wrapped acted as a fuse, its head terminated n a bullet which rested on the shoulder of the brass fuse that crewed into the shell, leaving an unfilled hollow space about the ullet. When the round shell struck any point, except that xactly in rear of the prolongation of the wire, put in the axis of he bore by using a sabot, the momentum of the bullet would raw the friction primer and explode the shell, regardless of the oint on which a round shell struck. A gun carriage was made or howitzers with a jointed trail, as thus they could be used as nortars, and fired at a high angle.

These were rather experiments than instances of success, and re only mentioned now to show that the ordnance officers did

Imfantry and Cavalry Arms, Accoutrements, Etc.

323,231	infantry arms.
34,067	cavalry arms.
6,074	pistols.
44,877	swords and sabres.
375,510	sets of infantry and cavalry accoutrements.
188,181	knapsacks.
478,498	haversacks.
328,977	canteens and straps.
115,087	gun and carbine slings.
72,413,854	small arm cartridges.
146,901,250	percussion caps.
69,418	cavalry saddles.
85,139	cavalry bridles.
75,611	cavalry halters.
35,464	saddle blankets.
59,624	pairs spurs.
42,285	horse brushes.
56,903	curry combs.

The enormous amount of "thirteen hundred field pieces of all descriptions" classed among the issues, does not signify that that number was manufactured at the arsenal, but that number includes all those obtained by manufacture, by purchase, or by capture, and afterwards issued therefrom. The writer in the *Enquirer* further says, "assuming that the issues from the Richmond arsenal have been half of all the issues to the Confederate armies, which may be approximately true, and that 100,000 of the enemy were killed, not regarding the wounded and those who died of disease, it will appear from the statement of issues, that about 150 pounds of lead and 350 pounds of iron were fired for every man killed, and if the proportion of killed and wounded be as one to six, it would further appear that one man was disabled for every 200 rounds expended. In former wars with the old smooth-bore musket it was generally said, 'his weight in lead is required for every man who was killed.'"

And from the issues of the arsenal it does not appear that the improved rifle requires a pound less.

It will appear to one fond of statistics, who may reduce the moving force of the projectiles to horsepower, that the force required to kill one man in battle will be represented by about one thousand horsepower.

Some general remarks in reference to the conclusion of the war and the destruction of the arsenal may not be out of place.

There was a large number of Federal prisoners in and about the city, Libby prison was filled with officers, and Belle Isle with many privates.

To release these was the object of cavalry raids against the city, when the main army was absent.

All the operators of the arsenal, and the Tredegar works, and employees of the departments were organized in regiments, and were called to the field when a raid was expected.

So they literally worked with their muskets at their sides,—and so valuable were the lives of the skilled artisans that it was said, if three iron workers in the regiment of the arsenal were killed the manufacture of cannon would stop.

But the end was approaching. In the Confederate Senate I remember listening to an animated discussion in regard to enlisting negro troops in the army.

It was urged by some of the senators that we should enlist and arm fifty thousand negroes, of course with a pledge of freedom.

I knew we could not possibly arm five thousand. The Ordnance Department was exhausted. One company of negroes was formed, and I witnessed the drill in the Capitol Square, but I understood as soon as they got their uniforms, they vanished in one night.

As the spring of 1865 approached the officers often discussed the situation. We knew that Lee's lines were stretched to breaking, we knew the exhausted condition of every department, and we knew the end was near.

Sunday, April the second, was a bright, beautiful, spring day, and Richmond was assembled at church. I was at St. Paul's church, about four pews in front of me sat President Davis, and in a pew behind him General Gorgas, Chief of the Ordnance Department and my chief. During service and before the sermon the sexton of the church, a well-known individual in the city, stepped lightly forward, and touching Mr. Davis on the shoulder, whispered something to him.

Mr. Davis immediately arose and walked out of the church with a calm expression, yet causing some little excitement. In a moment the sexton came back and called out General Gorgas. I confess I was made extremely uneasy, and was reflecting on the probable cause, when being touched on the shoulder, and looking around, the sexton whispered to me that a messenger from the War Department awaited me at the door.

I instantly felt the end had come.

I was ordered to report to the War Department, where I soon learned General Lee had telegraphed that his line was broken and could not be repaired, and that the city must be evacuated at 12 o'clock that night.

I was ordered to remove the stores of the arsenal, as far as could be done, to Lynchburg, and was informed that the President and chief officials would proceed to Danville, and the line be re-established between Danville and Lynchburg.

I immediately had the canal boats of the city taken possession of, and began to load them as rapidly as possible with machinery, tools, stores, etc., to be carried to Lynchburg.

As a large supply of prepared ammunition could not be taken, I had a large force employed in destroying it by throwing it in the river.

Supplies of value to families were given away to those who applied. By midnight the boats laden with stores were placed under charge of officers and started for their destination, which they never reached. What became of them I never knew.

About two o'clock in the morning General Gorgas, the Chief of Ordnance, came to the arsenal to tell me that he was about to leave with the President for Danville, and to report to him there. I never reported to him till fifteen years later, when I met him at Sewanee, Tenn., the Vice-Chancellor of the University of the South.

Every possible effort was made to prevent the destruction of the arsenal.

I, as commanding officer, visited every building between three and four o'clock in the morning of the 3rd of April, had the gas extinguished, and the guards instructed to shoot any man who attempted to fire the buildings.

One hour afterwards (I was then four miles from the city) the rapid and terrible explosion of the shells heard in the distance, proved that that part of the city occupied by the arsenal was being made desolate by the torch applied by the frantic mob. Shortly after the President left the city the gunboats were blown up.

After witnessing the explosion from the steps of the arsenal, I sent for the keeper of the magazine and satisfying myself that life would not be endangered by its destruction, wrote an order for him to explode the magazine at five in the morning, the last order of the Ordnance Department, and among the last orders of the Confederate Government, given in the city of Richmond.

As I rode out of the city in the early dawn, I saw a dense cloud of smoke suddenly ascend with a deafening report that shook the city to its center.

Thus ended the surrender of the city of Richmond.

The mob immediately took possession, looted the stores, and fired the city.

A large part of beautiful Richmond was burned to the ground.

The Federal troops marched into the burning city in splendid order, took possession, dispersed the mob and saved, by their energy and discipline, the city from total destruction.

HOWITZERS AND MORTARS FOR FIELD ARTILLERY, TO SUPPLY A NEED OF CURVED FIRE.

By Tiedemann, Major and *Abteilungs-Kommandeur* in the Posen Field Artillery Regiment, No. 20.

Jahrbücher für die deutsche Armee und Marine, October, 1897.

A. Is the Introduction of such pieces necessary?

I. LESSONS FROM THE HISTORY OF WAR.

In the combats and battles of the latter half of the present century, there is observable a growing tendency to make the most of the power of the fire-arms by occupying defensive positions strengthened artificially, either hastily or with care.

As instances of such defensive positions might be named: *Sebastopol*, which at the opening of the war of 1854 was still very imperfectly protected by earth-works; also the fortifications of *Vercelli*, *Palestro* and the bridge-head of *Turbigo* on the part of the French in 1859; and *Somma-Campagna* and *Chlum* on the part of the Austrains in 1866; and finally the field fortifications in the American War of Secession, 1861-1865.

Especially is the last named notable for the use made of field fortifications both on the offensive and the defensive. To protect themselves from the enemy's fire earthen parapets four to six feet high were thrown up, the earth being taken from both sides; a log was secured along the interior crest, and timber or heavy plank placed against it sloping to the rear, and good shelter thus obtained. The men soon perceived the value to themselves of the parapet and its shelter, and as a rule set about the construction without compulsion, often completing it in a night. A frontal attack following an insufficient artillery fire would invariably be repulsed, with losses that often amounted to fifty per cent of the troops engaged in the assault.

At *Atlanta*, *Richmond*, *Petersburg*, *Bunker Hill*, and *New Orleans*, such field fortifications were of great value, permitting considerably inferior forces to make a successful defence against superior numbers.

The French in 1870 instructed by this American experience made free use of intrenchments. The great losses the Germans suffered on their right wing and center on August 18, 1870, point clearly to the value of the fortifications the French had constructed here, though these fortifications in themselves were weak. The French long held their ground here, and suffered comparatively little loss, while on their right the 6th Corps, but little aided by field fortifications, gave way at the first German onset.

The influence of an artificially strengthened defensive position has no more conspicuous example than *Plevna* in 1877 in the Turko-Russian war. The field fortifications that the Turks constructed here held the Russians fast for 4⅔ months, though the reinforcements that came to the Russians as the siege went on made their numbers considerably more than the Turks. The latter were able nevertheless in the course of the siege to improve and strengthen their defenses. After the first unsuccessful assaults, the Russians when exposed to the Turkish fire had recourse to the very means the Americans had adopted on the offensive, twelve years before. As attackers, they intrenched themselves in the face of the enemy.

After the taking of the *Shipka-Pass*, the Russians found themselves forced to adopt the role of the defensive, and constructed field fortifications to strengthen their resistance. These proved of great utility, for here as with the Russians before Plevna, the Turks attempting to storm the works with superior numbers were broken up and repulsed at the line of defense of their enemy.

II. THE EFFECT OF LONG CANNON AGAINST FIELD FORTIFICATIONS.

Cannon with long bores are designed to fire at vertical targets, and the trajectory of their projectiles is as nearly horizontal as possible. From their nature therefore they are of little value against targets which are protected against an angle of fall of 20° or thereabouts. An angle of fall as great as this is first reached at 4000 m. (4375 yards) and at this range the probability of hitting is much less than at smaller ranges. Since the penetration of the shell of field guns is moreover slight, it is evident that little can be accomplished against field fortifications by this kind of fire, which up to about the year 1872 was the only kind in use.

Snrapnel then coming into general use, the possibility of hitting hidden targets increased, for to the angle of fall of the complete projectile must now be added one-half of the angle of the cone of dispersion of the shrapnel. But this seeming advantage was met by making the parapet somewhat higher, or the trench deeper. Besides this increased protection against artillery fire, icans in the war of secession, and these proved a complete protection against shrapnel fire.

Just as before, the field gun was effective against rifle pits constructed for men kneeling or lying down. But when the trench is deepened and more earth thrown on the parapet, such a cover is obtained that a man sitting with his back against the steep interior slope is entirely protected against the field gun firing shell and shrapnel.

Only in the artillery of those states that still have shell for their field guns would an attempt be made to destroy the parapet by crumbling down the crest or firing through it. Experimental trials in this line show that after the expenditure of much ammunition parapets from 2 to 3 m. (6½-10 ft.) thick will occasionally exhibit a furrow as wide as 2 m. (6½ ft.) at the top, and sometimes 1 m. deep; the thinner parapets are sometimes perforated by several projectiles striking at the same place, but for the most part the interior slope remains intact. Hence it follows that the defender sitting behind his parapet is almost completely protected against shell, and likewise against shrapnel at 4000 m. (4375 yards), if he is secure against an angle of incidence of 30°, for the angle of fall is about 20° and half the angle of the cone is 10°. At closer ranges than 4000 m. the probability of being hit is still less, for as the range decreases so also does the angle of fall.

The tactical precepts of nearly all the great European states teach that the artillery duel shall precede the infantry attack, and that the artillery after overpowering the enemy's guns shall direct its fire against his infantry. From what precedes we see that the defenders of intrenchments, which give cover against an angle of incidence of 30°, will suffer no loss, nor be shaken in their power of resistance, if they sit up against the interior slope.

The line of conduct of infantry stationed in intrenchments giving such protection is readily inferred. Sitting protected against the enemy's fire, they quietly await the issue of the artillery duel. If this turns out unfavorably to the defense, they remain sitting under cover until the assaulting troops have arrived at a distance of 300 to 400 m. (330-440 yards), the advance of these troops having been hindered as much as possible by that portion of the infantry of the defense not protected against an angle of fall of 30°.

It is understood here that field intrenchments like those of Plevna will seldom be met with, for such require as a rule more

than 12 hours work in their construction, and even when built can very frequently be turned. It *is* assumed however that adequate shelter trenches* for infantry and embrasures for artillery have been constructed at those points of the line of defense where the decisive struggle is apt to occur, or which are weakest either naturally or because they are thinly manned.

When the assaulting troops have arrived at a distance of 300 to 400 m. (330-440 yards) from the infantry of the defense that has hitherto been under cover, the latter step on the banquette and receive the enemy with a destructive fire at close range from magazine small arms. The shrapnel fire of the artillery of the attack cannot now be directed againt these unshaken troops of the defense, for the variation in the point of bursting of the shrapnel would make this fire dangerous for their own troops.

It is necessary further that from the *beginning* of the infantry attack the artillery of the offensive keep up an active cannonade against the troops in the shelter trenches to prevent their delivering an annihilating fire against the assaulting troops, who would be entirely exposed, while the defenders presented but the head.

To this last statement, it may be objected that shelter trenches skilfully constructed cannot be seen by the attackers at a distance of two or three kilometers (1¼ to 2 miles). It is to be observed, however, that the units of the defense in battle, whether infantry or artillery, are more or less confined to a single station, and so form an unbroken chain of infantry and batteries, without any large gaps. Where the ground is such that it will not permit of tiers of infantry fire in several lines one behind the other, the attacker will recognize the position of shelter trenches by the breaks in the chain of the defense. These breaks will be evidence of the presence of shelter trenches.

This leads up to the question where these trenches will be placed along the line of the defense. They should never be pushed forward of the front line; rather *in* the front line or behind it. When in the front line, they would appear to the attackers as gaps, provided the defense up to the critical moment of the assault concealed the fact that they were manned; if the trenches were behind the front line, they would be recognised by the fact that the supports going to the front as skirmishers would not pass over the ground across which the works lay. The existence of such works could also be discovered by a cavalry reconnaissance or by an observer in a captive balloon.

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* *Shelter trench* is used here and afterwards as the equivalent of *Deckungsgraben* in the original, which the author limits to such intrenchments as give protection against field guns firing shrapnel.—Trans.

The defenses can also be so prepared that when the artillery duel becomes hopeless, the defense can rapidly withdraw its guns out of reach of the enemy's fire, when the commander so orders. Of course before this is done, some losses will have been sustained, even though the pieces were served from trenches. Since it is not likely that the guns will be disabled by shell fire, and shrapnel works little injury to the material that will be sufficient to interrupt the fire, it follows that a superiority in artillery on the part of the attack cannot do more than *temporarily* silence the artillery of the defense. This can best be done by shrapnel. When the artillery of the defense is thus forced to cover, the material will be undamaged though the personnel has suffered. This last can be recruited quickly from the nearest line of troops, and the artillery will still be ready for action, and can reappear with all its guns against the infantry of the enemy when at the decisive moment the latter advance to the attack.

Thus also the artillery of the defense, if properly handled, can be made to render valuable aid when the decisive struggle comes, since the cannoneers sitting in the trenches have been more or less protceceted against shrapnel fire.

It appears therefore that field artillery is powerless against objects protected against a greater angle of fall than that of the projectile fired. It can only avail when the defenders are in trenches or behind parapets which fall off on the side away from the enemy at an angle under 20° to 30°, and thus, not covered from the artillery fire, they are shaken when the decisive attack comes.

The history of war furnishes proof for the statement that field guns fail against field fortifications and troops under cover. In the American Civil War, field guns proved quite inadequate, and in the Turko-Russian War the Russians at Plevna could gain no success with 170 field guns against the 100 of the Turks. Later on the Russians brought up 20 siege guns which played on the gradually strengthened works of the Turks, but with no better success. Before their third unsuccessful assault the Russians cannonaded the Turkish works for several days with 450 pieces, to which the Turks as before could reply with only one hundred; but in spite of this superiority in guns, the Russians had nothing to show for it, for the Turkish infantry took to cover against the artillery fire, and when cover was not at hand for their artillery, it changed its position from time to time, compelling the Russians to a protracted unavailing cannonade.

This work of the artillery gained the Russians nothing but brought many direct disadvantages. Kuropatkin sums them up thus in his "*Kritische Rückblicke auf den russisch-türkischen Krieg,* 1877-78"; 1. As regards material, the Russians wasted 20,000 projectiles, and many guns and other material were rendered unserviceable; 2. the Russians lost much in morale, in the conviction that the fire of their artillery, on which they based many hopes, was ineffectual; 3. the artillery lost confidence in its leaders, in its guns, and in itself; and 4. the infantry gave up hope of receiving aid and support from the artillery; 5. finally valuable time was lost, as a consequence of the unprofitable work of the artillery.

On the other hand the Turks gained in many respects: first, in morale, the Turks were convinced of the failure of the more numerous Russian artillery; second, in material, they lost few men, their works suffered little in resisting capacity, and they found they were able to establish new fortifications under the very eyes of the Russians.

When the Czar, after the Russians had lost 30,000 men before Plevna, gave the command to General Todleben, the successful defender of Sebastopol, this general raised the strength of the artillery up to 508 field and 45 siege guns; but this great array of guns was unable to do more than render it more difficult for the Turks to strengthen their works by day. The insufficiency of long cannon firing against field fortifications, even when the caliber of the guns classes them as siege guns, is clearly shown by the fact that Osman Pasha did not surrender until three months later, and then only on account of the failure of victuals and ammunition, after being quite hemmed in by the Russians.

The Turko-Russian War furnishes other examples than Plevna of the inadequacy of long cannon. At Gornji-Dubniak four thousand Turks with 4 guns defended a site strengthened by rifle pits and 2 redoubts against 20,000 Russians, who surrounded their position and bombarded them for half a day with 60 guns. Though the profile of these works was weaker than that of the works at Plevna, the assault of the Russians that followed their cannonade was repulsed. Though new columns were led to the attack, it was not until darkness began to fall, that the Turks failing to receive assistance from their main army, were driven off the field or taken prisoners. Nevertheless their losses were not great, while those of the Russians amounted to 3,300 men, nearly as much as the whole strength of the garrison.

The result was the same at Telish, where 56 Russian guns fired against the intrenched position of 5 Turkish battalions for nine hours, and accomplished almost nothing.

It was stated in the account of Plevna that the siege guns that the Russians brought up had no especial effect. Of course by the time the Russians had brought up these heavy guns, the works had no longer entirely the character of field fortifications for the profile of fortifications will naturally be strengthened when the enemy waits not merely a day, as is generally the case in the field, but is held at bay for weeks and even months. Especially in strength of parapet and increased cover for the defenders light fortifications will assume more or less the character of semi permanent works. As this change progresses the possibility diminishes of acting successfully with field guns against the defenders of such works.

Long cannon of large caliber in spite of the increased energy that comes with their flat trajectory are not much more effective than field guns, for while they are good against vertical targets they are not so against horizontal targets, and troops sitting in shelter trenches must be regarded as horizontal targets. Moreover the strongest line of resistance of the parapet protecting the defenders is directly in the line of the projectile's trajectory The caliber of guns capable of transportation in the field is not as a rule, sufficient to destroy this shelter; so heavy guns, with a trajectory still flatter than that of the field guns, are equally unsuccessful in attaining hidden targets.

Not only does this fact weigh against the supplementing o the fire of field guns by that of long heavy cannon, but it mus also be remembered that while these heavy guns can be moved easily enough along well paved roads, yet their mobility is uncertain when they leave the roads and are sent across country Arms of offense that in the field are moved at a slow pace and with much difficulty are of little value in the quick changing phases of a campaign. If the ground was soaked by a long rain they would stick in the mud. They could not therefore fulfi the requirements imposed on field and likewise in this case on these long heavy cannon, *viz., to open fire at the right time from th right place.*

Still other considerations work against the use of long heavy cannon against hidden targets. Among these are, the difficulty of supplying ammunition and their slowness of fire.

For a caliber of 15 cm. (5.9 inches) the projectile weighs about 40 kg. (88 lbs.), for one of 12 cm. (4.72 inches) about 20 kg. (44 lbs.). As the limber cannot be loaded to an extent that will interfere with the mobility of the piece, we may estimate 8 rounds with the gun for the 15 cm. caliber, and twice as many for the 12 cm. caliber. Likewise the caisson of the 15 cm. gun will carry 8 rounds in its limber and 16 rounds in the caisson-body, in all 24 rounds; the 12 cm. gun will carry twice as many. In long engagements there would be a danger of the ammunition running out if a reduction in the rapidity of fire did not ensue when the caliber is increased, for it becomes more difficult to bring the ammunition up to the guns in the first line, and the loading and aiming requires more time. The evil might be partially remedied by increasing the number of caissons assigned to each battery, but on the other hand this would unduly lengthen out the column, especially with the 15 cm. gun.

In a contest between a heavy battery of long cannon and field guns, the former would be at a disadvantage on account of their slower rate of firing. A field battery delivers ordinarily 4 rounds per minute; this may rise as high as 15 rounds in the exigency of battle. A 15 cm. (5.9 in.) battery, on the other hand, standing on platforms delivers about one shot in three-fourths of a minute; without platforms, the rate would be still less. In spite of the far greater number of bullets that each shrapnel of the larger caliber carries, the field battery will reply in a given time with a greater number, and the issue of such a duel cannot remain doubtful, for it rests on disabling the cannoneers.

From all that has now been said it follows, that neither field guns nor long heavy cannon, firing shell or shrapnel, are capable of shaking troops protected against an angle of fall greater than that of the projectile, nor are they able to prevent an active defense when the decisive attack is made. The destruction of the earth works of the defense is not possible even with heavy guns. These heavy guns firing against troops under cover are, on account of their flatter trajectory, not only not better, but generally inferior to an equal number of field guns, and in the artillery duel this relation does not change. To this inferiority must be added their greater weight. It must be kept in mind, however, that we are speaking of the employment of heavy cannon on the offensive, not on the defensive. With the latter, the conditions are much more in favor of the long cannon.

III. THE EFFECT OF CURVED FIRE CANNON AGAINST CONCEALED OBJECTS.

Troops sitting with their backs against a parapet are just as ready for action as those standing in the trenches; in case of an attack, the former need but to stand on the banquette and open fire. To avoid shrapnel fire therefore from long cannon, troops remaining in shelter trenches will quickly take advantage of the protection the parapet offers them. They thus become horizontal targets for the attacker, and must be reached with artillery in order that the effect of their fire will not be felt by the offensive at a time when it would be most unseasonable and mischievous.

Now the probability of hitting horizontal targets increases with the angle of fall; and for smaller ranges, only howitzers and mortars have a large angle of fall. Hence these species of cannon appear best adapted for the horizontal target.

Just as ever, it will still be the rule in a campaign that the targets of artillery will be vertical and in the open; but in exceptional cases, the garrison of shelter trenches will take cover and the guns be withdrawn. Both of these conditions must be prepared for; and this would be done, if, to the larger number of field guns that an army carries in the field, there was added a small number of curved fire cannon. And were this done, it would be but returning to an organization which we already once possessed; for in the days of spherical shell, in addition to the long guns which were their main armament, the field artillery was also supplied with howitzers to seek out objects in dead angles.

Returning now to the lessons of the history of war, we find the following facts based on an account by an officer of artillery in the Northern Army during the American War of Secession. With the Federal Army were certain Coehorn mortars which were used against the Confederate troops, when the latter were intrenched in field works with strong profile, since it was found that long cannon made no impression on the garrison. The longer the war continued, the more were the utility of these mortars and their ease of conveyance prized. Hence there at last arose a constant pressing demand for Coehorn mortars,—yet these light portable mortars fired only shell.

Especially since the experiences of the Turko-Russian war, military writers have called for the introduction of curved fire cannon to effectively cannonade field intrenchments. Thus Boguslawski says in "*Die Hauptwaffe in Form und Wesen*"; "In the *Development of Tactics* (Part 2, Vol. 3), I expressed the view that the introduction of an improved curved fire cannon for use in the field against the ever increasing number of intrenchments, was not one of the impossibilities; this opinion did not deserve the fine contempt it received on so many sides.

"It makes little difference whether the curved fire cannon move with the other artillery, or follow in small parks immediately in rear of the army. The idea is the same, and is this,—not only in front of permanent works but also before field intrenchments, as soon as the enemy, after the manner now customary, takes refuge behind ramparts or in trenches, there arises a need, and an immediate need, for howitzers or mortars to open a vertical fire, that can penetrate their overhead cover, and reach the ground close behind the parapets.

"We are fimly convinced that curved fire cannon for field use will again be introduced in one way or other through urgent necessity."

Nearly all military writers now take it for granted that in the next war there will be an extensive use of field fortifications.

The necessity of adding a limited number of curved fire cannon to the long guns of the field artillery is brought out in detail by Major Lydhecker in a paper that obtained the prize in the prize essays for artillery officers 1885-87, and which was entitled: "Curved Fire in field and siege warfare, especially against field intrenchments."

The author of "*Detached Batteries for the Army in the Field*", in the *Jahrbüchern für die deutsche Armee und Marine* (1890), expresses himself thus: "The magazine small-arm justifies every stroke of the spade, for thereby cover is obtained that makes it invincible. Contrary to the state of things in former times, intrenching tools at the present day constitute a capital that bears interest every hour. Hence where the defender in times past allowed the troops to rest in what time was at his disposal, nowadays he will employ it in causing his troops to intrench themselves, rightly judging that the sweat of the brow before the battle will in large measure control the fate of the day. It is probable then that in a future war unprepared battle fields will be the exception, and in many of them the changes wrought in the plan and profile of the terrain will be of considerable magnitude. To shake and weaken the defender's power of fire, which is necessary to prepare for the decisive attack, becomes a peculiarly difficult problem for the artillery."

It is further shown in this essay that curved fire pieces are effective even when the projectiles pass clear over the shelter, so that the possession of such special pieces becomes indispensable for an army in the field. A piece with a steeply curved fire is to be preferred, for this has the further advantage that the attacker can advance close up to the lines of defense, while these are still under fire, without himself running a risk from his own artillery.

The same periodical that contained the foregoing essay. printed in 1894 an article by Major General Speck entitled, "The Direction of the Movement and of the Fire of Heavy Artillery in the attack of fortified lines of defense." In this the author says that there is little doubt that since the Turko-Russian war the strengthening of positions by fortifications will receive an application more extended than ever before. Also, when, in a campaign, opposed to a swift advancing offensive, the defense finds itself suddenly forced to stand and await the attack in an unprepared position, it will still seek to strengthen the position by hasty intrenchments and other means at hand. This situation will no longer be the exception to the rule, and hence the field artillery to overpower such positions must have light cannon with steeply curved fire.

In this respect there has been a complete revolution in siege artillery since twenty-five years ago, at which time its rifled cannon were almost exclusively long guns, rifled mortars first appearing on the stage before Strasburg in 1870. Curved fire from howitzers and mortars has in a large degree replaced long cannon for firing against concealed targets, and on the whole has come decidedly to the front. Accordingly we now find in siege trains destined for the armament of a fortress, a large number of rifled howitzers and mortars. This step could the more readily be taken in siege artillery because,—apart from the better action of curved fire cannon against the numerous concealed targets presented in a siege,—the introduction of these new pieces increased the mobility of a large part of the siege artillery, without impairing the simplicity of its equipment, appurtenances, and ammunition supply.

Lieutenant-General Müller, speaking of the effect of the smooth-bore mortars at Sebastopol in his "Geschichte des Festungskrieges," says: "The mortar fire was very effective on both sides, especially in its destruction of embrasures and platforms; the little Russian mortars were particularly annoying to the attack. In a similar way he speaks of the effect of the remarkably large use of smooth-bore mortars before Strasburg:

"The mortar fire kept on increasing. During the first period of the attack (till September 10) the daily expenditure of bombs rose from about 400 up to 1200 or 1300; at the end of the second period (September 20) it had reached 3000. Of course among these were many quite light ones (15 cm = 5.9 in.), of which latter for example 1644 were fired from the 17th to the 18th of September."

In treating of the period between 1870-1885, after mentioning the increase in effectiveness through using shrapnel for the 15 cm. rifled mortars, the same author says:

"The men and guns in batteries and behind ramparts hitherto secure against all other kinds of fire were now exposed to extermination to a degree unknown before. This power of the mortar came first clearly to light in Germany in 1880, after the 21 cm. (8.27 in.) mortar had been more extensively employed in the maneuvers, and about this time it was demonstrated that the fire of heavy mortars destroyed a battery more rapidly than a direct fire from 12 and 15 cm. (4.72 and 5.9 in.) cannon."

General von Sauer expresses his views in his works of the early eighties thus: "Many conditions for the defense have been totally changed by the introduction of rifled mortars. For the artillery attack of fortifications, the chief reliance between the ranges of 4000 and 2000 m. (4400 and 2200 yards) must be placed on mortar and shrapnel fire."

He remarks in his "Beiträgen zur Taktik des Festungskrieges": "'Could the opening of the artillery attack at once follow the investment, there would be a marked shortening of the attack. For this purpose field artillery would have to be employed, and this would have to possess howitzers."

For the period since 1885 Lieutenant-General Müller says: "'The system of cannon of the large artilleries described for the preceding period now received a change in its composition; curved fire pieces were increased in number, those with flat trajectory were diminished."

From what has been cited it will be seen, that in *siege artillery* curved fire cannon have achieved a constantly increasing importance at the expense of the long guns, due to the increased shelter both as regards the angle of fall of the projectile and the actual resistance of the cover itself.

What is true of the effectiveness of plunging fire in the siege and defense of permanent works will also hold good in a campaign. Indeed plunging fire will perhaps be more effective here in so far as the targets are either living or if material are of comparatively little resistance (as guns and light overhead cover); it will perhaps be less effective, on the other hand, since the objects shot at are not so broad or so deep as with siege artillery.

Before giving examples of trials that have taken place with the object of comparing the effect of field guns and field mortars, we will first examine the mode of attack on field fortifications when curved fire cannon accompany the army in the field.

The troops behind cover are exposed to the curved fire during the whole time preceding the infantry attack. They are under an effective shrapnel fire whether sitting behind the parapet or in the case of infantry when standing upon the banquette. In the latter case the long cannon might share in the firing, if the infantry of the attack has not advanced so far as to be in danger from their own artillery fire (300-400 m., 330-440 yards). In this event, however, the curved fire can be maintained against the same objects as before, because in consequence of the great angle of fall the longitudinal dispersion of the shrapnel is small, even when the point of bursting of the shrapnel is comparatively high. Supported by this continuing fire the infantry of the attack can advance nearer than 300 m. (330 yards) to the enemy's position, because by a small increase of the elevation and length of fuze, the shrapnel can be made to burst so that none of the bullets fall in front of the parapet, while on the ground close behind it they fall thickly. Hence precisely at the critical moment of the attack the foremost line of the defense and the reserves coming forward to its support can be held in check.

If the attack is defeated, the reverse will be less serious if curved fire is thus present than if the artillery consisted exclusively of cannon that must cease firing at the most critical moment, or else, by increasing the elevation, fire several hundred yards behind the line at supposed reserves who at this time may be close up to the front line.

It cannot be doubted that curved fire will give a sufficiently large angle of fall to successfully cannonade concealed targets, since the 15 cm. (5.9 in.) mortar with lesser elevations and corresponding loading gives an angle of fall of over 30° at 1700 m. (1880 yards), and the 15 cm. howitzer gives the same angle at 2600 m. (2850 yards). When these pieces are fired with shrapnel, the angle of fall of the complete projectile must be increased by half the angle of the cone of dispersion. With a small final velocity the total angle of the cone is about 30°. Hence, the steepest requisite angle of fall (45°) for the shrapnel is obtained at medium ranges.

We will now give some comparative trials of field gun and mortar firing. These tests took place in Russia in 1882; they were made against an earth-work with 244 targets representing the defenders.

Piece and Ammunition.	Number of hits in targets representing cannoneers.
1.—108 shell and shrapnel from 12 light field guns.	30
2.—144 shell and shrapnel from 16 heavy field guns.	40
3.— 72 shell and shrapnel from 4 light and 4 heavy field guns.	7
4.— 40 shell from two 15 cm. mortars.	19
5.— 40 shell from the 10.67 mortar.	7

The range is missing in this table, but it is likely that it was the same for all five firings; otherwise there could be no comparison of them. It is also to be noticed that in the first three firings, both shell and shrapnel were used, but it is not stated how many were shell and how many shrapnel. Probably shell was employed to get the range, and the fire continued with shrapnel as the more efficient projectile. With the mortars, on the other hand, only shell is used, apparently because the construction of shrapnel for mortars was not settled at that date. While the five firings are thus open to objections, yet as far as so small a number of shots permits, we may draw some inferences.

Taking the hits made in the fourth firing as the standard, at the same ratio of hits per shot there would have been 51 hits in the first firing, 68 in the second, and 34 in the third. In other words, this signifies that the mortar was more effective.

The work of the 10.67 cm. (4.2 in.) mortar is considerably behind that of the 15 cm. (5.9 in.) caliber; it is better than the third firing however, though it falls behind the first and second. This inferiority is due to the fact that the smaller caliber mortar does not fire as accurately as the large caliber, and its shell does not give as many pieces on bursting; moreover the mortars were firing shell, and not shrapnel, which is so much more effective. If shrapnel had been used, it is not unlikely that the effect of the fourth firing would also have been greater.

A more severe comparison of these trials might be made, not based on the number of shots and their effect, but on the weight of metal fired; ths firings number 4 and 5, would here be superior. The comparative numbers for the five firings are these:

for one shot fired, the hits are in order 0.27— 0.28— 0.1— 0.5 and 0.17; for a hundred weight of metal, 2.25— 1.2— 0.51— 1.2 and 0.42. The work of the 15 cm. (5.9 in.) mortar is in this last case as good as the firing of No. 2, in spite of the fact the mortar fired only shell. That shrapnel is effective against such concealed targets some examples that are given further on will amply prove.

We will now give the effect of the projectiles in the above trials against the material. The following numbers give the relative value of the destructive effect on the material, of these five firings in order; corresponding to one projectile fired, 0.1— 0.23— 0.125— 4.5— 1.0; for one hundred weight of metal, the relative values are, 0.9— 1.02— 0.66— 9.9 and 2.4. Here the shell fire with percussion fuze naturally is more effective than the shrapnel.

A further comparative trial in Russia again shows the superiority of curved fire over horizontal fire against concealed targets.

	Range. m.	Piece and Ammunition.	Number and kind of Targets.	Targets Damaged.	
				total.	per shot.
	1600	Heavy gun, 18 shell.	59 standing	7 standing	0.25 standing
		Light gun, 18 shell.	59 sitting	0 sitting	0 sitting
	1600	Heavy gun, 18 shrapnel.	Same	5 standing	0.14 standing
		Light gun, 18 shrapnel.		6 sitting	0.16 sitting
Mean of four firings.	1600	15 cm. mortar, 20 shell.	Same	? standing 4.5 sitting	? standing 0.22 sitting
	1600	10.67 cm. mortar, 20 shell.	Same	? standing 4.75 sittnig	? standing 0.23 sitting

In the above table it is not stated against what angle of fall the standing and sitting targets were protected, we cannot therefore draw any certain conclusions respecting the power of the two kinds of firing. The test seems to indicate however that the mortars firing shell are very nearly equal in effect to the guns firing shrapnel.

About ten years ago, Krupp made some experimental tests of 12 cm. (4.72 in.) field howitzer and 15 cm. (5.9 in.) field mortar fire. The target was one used for testing siege guns, and consisted of a sunken battery for six guns. Two of these last (numbered 5 and 6) were in a row at right angles to the line of fire, the other four were in a row at an angle of 45° with the first vo. The object of this disposition was to compare frontal and alf lateral fire in attacking a position. In the test we now speak f, only shrapnel was used. The targets for the most part were rotected against only very small angles of fall; such targets as ad protection against an angle as much as 22° showed ttle damage; none of the targets were protected against an ngle of fall as great as 30°. Corrections were also made on the asis of observations on the target, which of course could not all be done in war; moreover the results of the shrapnel with 5 g. and 26 g. bullets are combined. The guns had each targets representing cannoneers. The parapet was 2 m. (6½ .) high, and at its foot stood some targets 1.8 m. (5.9 ft.) high, hich were protected against an angle of fall of 22½° (how many f these is not stated). The targets representing the men at the uns were protected against an angle of fall of 9° or 10°. Of the argets at the four guns oblique to the line of fire (numbered 1 to), those targets up against the parapet were protected against 5°, the foremost targets representing the cannoneers, at guns No. , 2 and 3, were protected against an angle of fall of 9° or 10°. umbers 1 and 6 of the guns being on the flanks were the least hot at, in order to increase the probability of hitting. The ecord was divided thus, (*a*) number of cannoneers hit, (*b*) total umber of hits in these targets, (*c*) hits in the vicinity (between he men and four yards back), (*d*) hits in the targets at the foot f the parapet. The height and horizontal distance of the point f bursting is measured from the interior crest of the front arapet.

I. 12 cm. (4.72 in.) howitzer. Weight of shrapnel 16.3 to 16.6 g. (35.9-36.5 lbs.). Contents, 460 hard lead bullets of 16 g., or 85 bullets of 26 g. Bursting charge, 200-215 g. (7 to 8 oz.). nitial velocity with 0.5 kg. (1.1 lb.) of coarse grained powder $\frac{6}{10}$ mm.), was 140 m. (460 ft.); with 0.6 kg. (1.32 lb.) powder, initial velocity was 161 m. (528 ft.); with 1 kg. (2.2 lb.) powder, 225 m. (738 ft.); with 1.5 kg. (3.3 lb.) powder, 290 m. (950 ft.).

Firing at 1500 m. with the 12 cm. howitzer.

Charge.	No. of shot	Weight of bullet.	Elevation degrees.	Lateral allowance.	Time of fuse.	Point of bursting.		HITS.								
								At Piece No.							Total.	In the battery.
kg.		grm.		points.	sec.	height	hor. dis.		I	II	III	IV	V	VI		
0.5	1	16	22.5	22	11.0	—40	16	a	3	1	2	5	6	—	17	77
								b	3	2	2	5	9	—	21	
								c	7	5	7	10	13	—	42	
								d	—	—	2	4	8	—	14	
	2	16	22.5	25	11.0	—60	15	a	—	1	—	2	4	1	8	34
								b	—	1	—	3	5	4	13	
								c	—	2	2	6	5	3	18	
								d	—	—	1	1	1	—	7	
	3	26	22.5	22	11.0	—50	14	a	1	—	2	2	—	1	6	41
								b	1	—	2	4	—	1	8	
								c	2	4	3	12	5	—	26	
								d	—	—	—	5	1	1	7	
	4	26	22.5	22	11.0	—45	11	a	—	1	—	—	—	—	1	
								b	—	1	—	—	—	—	1	
								c	—	1	—	3	1	2	7	
								d	—	1	3	—	—	—	4	
	5	26	22.5	25	11.0	—60	14	a	—	1	2	4	4	—	11	
								b	—	1	2	5	4	—	12	
								c	—	1	3	9	7	—	20	
								d	—	—	—	1	—	—	1	
1.0	6	26	8.6	8	6.5	—160	16	a	—	—	1	1	3	—	5	
								b	—	—	1	1	5	—	7	
								c	—	—	—	1	2	—	3	
								d	—	—	—	—	—	—	—	
	7	26	8.8	8	7.0	—60	11	a	—	—	—	—	—	3	3	
								b	—	—	—	—	—	3	3	
								c	—	—	—	—	—	1	1	
								d	—	—	—	—	—	—	—	
	8	26	8.7	0	7.2	—25	4	a	—	—	3	3	2	1	9	
								b	—	—	4	8	6	1	19	
								c	—	1	3	10	5	—	19	
								d	—	—	—	3	—	—	3	
	9	16	8.7	0	7.1	-40	8	a	—	1	3	6	2	—	12	
								b	—	1	3	8	5	—	17	
								c	—	2	3	20	5	—	30	
								d	—	—	—	7	—	—	7	
	10	16	8.7	0	7.1	—45	8	a	—	—	2	5	4	—	11	
								b	—	—	2	17	6	—	25	
								c	—	5	6	5	3	—	19	
								d	—	—	—	10	1	—	11	

If we add the numbers opposite a and d for each charge, we find for the 0.5 kg. (1.1 lb.) los at 1500 m. for the five shots, 43 cannoneers and 29 of the infantry at the parapet were hit; fo. 1.0 kg. (2.2 lb.) charge at same range and for same number of shots, 40 cannoneers and 21 infan were hit. Summing up the total number of bullets striking within the limits of the battery, find 197 for the 0.5 kg. charge, and 164 for the 1.0 kg. charge. It is to be observed that the cann eers at the siege battery here used as a target are crowded together in half the space the men o field battery would occupy. The effect of each shot was increased by this.

Firing at 1900 m. with the 12 cm. howitzer.

No. of shot	Weight of bullet.	Elevation (degrees).	Lateral allowance.	Time of fuse.	Point of bursting.		HITS.								
								At Piece No.						Total.	In the battery.
	grm.		points.	sec.	height	hor. dis.		I	II	III	IV	V	VI		
1	16	25.1	25	13.5	—50	0	a b c d	Too short.							
2	16	26.3	25	13.5	—60	23	a b c d	To the right, 88 hits in 33 m. length.							
3	16	26.3	40	13.5	—60	25	a	1	2	—	1	—	—	4	15
							b	1	2	—	1	—	—	4	
							c	2	3	5	1	—	—	11	
							d	—	—	—	—	—	—	—	
4	16	26.1	50	13.5	—35	6	a	—	1	—	—	—	3	4	7
							b	—	2	—	—	—	4	6	
							c	—	—	—	1	—	—	1	
							d	—	—	—	—	—	—	—	
5	16	25.4	30	13.4	—50	8	a	1	—	3	1	—	—	5	32
							b	1	—	4	1	—	—	6	
							c	9	8	6	1	1	—	25	
							d	—	—	1	—	—	—	1	
6	26	25.4	35	13.4	—60	18	a	—	1	1	6	5	—	13	38
							b	—	1	1	7	8	—	17	
							c	—	—	3	5	9	1	18	
							d	—	—	—	1	2	—	3	
7	26	25.4	40	13.4	—25	9	a	—	1	1	4	7	—	13	126
							b	—	1	1	7	30	—	39	
							c	—	—	5	24	43	—	72	
							d	—	1	—	4	10	—	15	
8	26	25.4	40	13.4	—40	18	a	—	—	—	2	2	3	7	43
							b	—	—	—	2	4	3	9	
							c	1	4	—	8	7	9	29	
							d	—	—	—	1	4	—	5	
9	16	12.1	12.0	9.3	—90	14	a	2	1	1	2	—	—	6	10
							b	3	2	1	3	—	—	9	
							c	—	—	—	1	—	—	1	
							d	—	—	—	—	—	—	—	
10	16	12.1	12.0	9.5	—55	13	a	—	—	3	5	5	—	13	49
							b	—	—	4	13	6	—	23	
							c	—	3	4	11	8	—	26	
							d	—	—	—	—	—	—	—	
11	26	12.0	12.0	9.5	—10	5	a	—	1	—	1	2	—	4	19
							b	—	1	—	1	2	—	4	
							c	—	—	—	8	7	—	15	
							d	—	—	—	—	—	—	—	
12	26	12.0	12.0	9.5	— 2	0	a	—	—	—	—	4	—	4	137
							b	—	—	—	—	58	—	58	
							c	—	—	—	—	79	—	79	
							d	—	—	—	—	—	—	—	

With the 0.6 kg. (1.32 lb.) charge at 1980 m. range for 6 shots, 46 cannoneers and 24 infantry at rapets were hit; for the 1.0 kg. (2.2 lb.) charge for 4 shots 27 cannoneers but no infantry were In the entire space of the battery there fell 255 bullets in the first case, and 213 in the second ne gun was disabled.

II. The 15 cm. (5.9 in.) mortar. The shrapnel weighed 31.55 to 31.75 kg. (69 to 70 lbs.), containing 500 hard lead balls of 26 g. weight. The bursting charge was between 310 and 410 g.; initial velocity for 0.75 kg. (1.65 lb.) charge was 135 m. (445 ft.) 1.0 kg. (2.2) lbs.), 163 m. (534 ft.).

Firing at 1500 m. with the 15 cm. mortar.

Charge.	No. of shot	Elevation (degrees).	Lateral allowance.	Time of fuse.	Point of bursting.		HITS.								
							At Piece No.							Total.	In the battery.
kg.			points.	sec.	height	hor. dis.		I	II	III	IV	V	VI		
0.75	1	25.3	25	11.6	—75	22	a	—	3	1	2	3	3	12	45
							b	—	3	1	2	3	3	12	
							c	—	3	7	3	6	10	29	
							d	—	—	1	3	—	—	4	
	2	25.3	25	11.6	—55	20	a	—	2	4	3	3	—	12	65
							b	—	2	5	3	3	—	13	
							c	9	5	9	9	6	1	39	
							d	1	2	5	3	2	—	13	
	3	24.8	25	11.6	—60	16	a		1	2	—	1	—	5	56
							b	3	1	2	—	1	—	7	
							c		8	6	5	7	2	39	
							d	1	2	4	—	3	—	10	
	4	24.8	25	11.6	—60	14	a		1	3	2	1	—	6	21
							b		1	3	2	1	—	7	
							c	4	1	3	4	1	—	13	
							d		—	1	—	—	—		
	5	24.8	25	11.6	—70	16	a	2	—	1	6	1	—	10	46
							b	2	—	1	9	2	—	4	
							c	4	4	3	9	4	—	24	
							d	—	—	—	7	1	—	8	

Firing at 1975 m.

Charge.	No. of shot	Elevation (degrees).	Lateral allowance.	Time of fuse.	height	hor. dis.		I	II	III	IV	V	VI	Total.	In the battery.
1.0	6	23	30	12.7	—75	18	a	—	1	1	4	1	3	10	68
							b	—	2	1	5	1	3	12	
							c	2	7	6	14	10	8	47	
							d	—	—	—	4	3	2	9	
	7	23	25	12.7	—80	20	a	—	2	1	2	3	2	10	68
							b	—	2	3	3	3	2	13	
							c	2	9	10	8	10	10	49	
							d	—	2	2	2	—	—	6	
	8	23	25	12.7	—70	22	a	1	1	3		—	—	5	42
							b	1	1	3		—	—	5	
							c	4	9	7	10	3	3	36	
							d	—	—	—		—	—	1	
	9	22.8	25	12.7	—65	16	a	—	3	3	5	3	—	14	67
							b	—	4	5	7	4	—	20	
							c	5	7	12		5	—	40	
							d	—	—	1	4	2		7	
	10	22.8	25	12.7	—75	18	a	1	3	5	2	—	3	14	69
							b	1	3	7	3	—	3	17	
							c	8	13	9	9	5	2	46	
							d	—	1	3	2	—	—	6	
	11	22.8	25	12.7	—55	14	a	6	5	3	5	5	—	24	88
							b	6	5	5	7	8	—	31	
							c	10	11	12	5	8	—	46	
							d	1	1	3	4	2	—	11	

With the 0.75 kg. (1.65 lbs.) charge at 1500 m. (1640 yds.) for five shots, 45 cannoneers and 36 of the men at the parapets were hit, for the 1.0 kg. (2.2 lb.) charge at 1975 m. (2160 yards) for six shots, 77 cannoneers and 40 of men at the parapet were hit. At the 1500 m. range, 233 bullets fell within the limits of the battery; for the 1975 m. range, 402 bullets fell within these limits.

If we reckon here on the basis of the weight of ammunition fired, we find for the 12 cm. (4.72 in.) howitzer at 1500 m. for the 0.5 kg. (1.1 lbs.) charge, that 0.47 cannoneers and 0.25 infantry soldiers were hit per 1 kg. of iron. If we take the 100-weight as our unit in order to compare the results with the Russian firing, we find 26.0 cannoneers and 17.5 infantry hit per 100-weight of metal for the less charge, and 23.5 cannoneers and 12.5 infantry hit for the greater charge. The results for the 1980 m. range are likewise good as regards the number of cannoneers hit; for the larger charge, however, no infantry were hit at this range.

For the 15 cm. (5.9 in.) mortar at 1500 m. range with the smaller charge, we find 0.28 cannoneers and 0.22 infantry hit per 1 kg. of iron; for the larger charge, 0.40 cannoneers and 0.20 infantry were hit. With a 100-weight as the unit, we find these four numbers, 14.0, 11.0 20.0, 10.0.

These numbers seem to indicate that shrapnel fired from mortars and howitzers with an approximately correct adjustment of the point of bursting has tenfold the effectiveness (in a cross-section) of shell fired from the same pieces. Of course there were not enough shots fired to warrant a final conclusion; for this a far greater number of projectiles must be fired, and war conditions simulated.

From the Krupp tests, the howitzer seems a little superior to the mortar. Between guns on the one hand, and mortars and howitzers on the other, as we have shown in sections II and III, the latter class of cannon are undoubtedly superior, at least so far as the small number of comparative trials that have taken place permits us to draw any conclusion. The only question would be whether such or similar results in firing would be obtained under war conditions.

[Translated by Second Lieutenant *George Blakely*, Second Artillery.]

(TO BE CONTINUED.)

NATIONAL DEFENSES.

By Major-General MAURICE.*

We have to thank a great American writer, Captain Mahan, for an historical lesson as to the conditions under which Britain had to fight in the past. He has shown that as long as she was supreme at sea, attacks upon her commerce, though they might severely wound her, could not prevent her from striking far more deadly blows at an opponent than any that could be delivered against her. The fact of an opponent being reduced to a war against commerce implied such a disadvantage to him that though the struggle might be long and hard, the Mistress of the Seas was practically certain to emerge from it victorious and with larger compensations for her many losses.

His history of the great struggle of our forefathers against th power of Napoleon cannot be too strongly commended to the careful consideration of all those who would wish to realise the position of Britain to-day. But it is necessary also to realise the effect of the changes that have taken place since that great struggle occurred.

In the first place, the conditions of life upon the Continent have altogether changed. The creation of railways, telegraphs, and other means of communication, as well as the development of commercial life, have no doubt made Continental nations in some respects far more independent of the sea, for the actual means of living, than they were in the days of Napoleon. But, on the other hand, the habitual consumption of articles of tropical produce, coffee, sugar, tea, has become universal, and for these and many other things sea transport is still indispensable. It may almost be doubted whether, taking all things into consideration, more especially the developed necessities of civilisation, the loss of all sea transport would not be felt more severely in the present time than it was then. On the other hand, the whole peace conditions of the Continent have been prepared and adapted for war to an extent that was hardly possible even during the long reign of war from 1789 to 1815. Taking, however, into account the way in which the forces on the Continent are now arrayed against one another, it may be reasonably doubted whether the power of Britain, if it be properly used in behalf of the liberties of the world, is not still as great, except in one respect to be noted immediately, as Captain Mahan has shown that it was during the great war. The forces, therefore, which are apt to impress British men with the idea that we are already reduced to the position of a state like Belgium, and can only look on in helpless impotence at the struggles of stupendous masses, are by no means so invulnerable to the pressure of Britain as they are apt to be assumed to be.

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The one exception which has to be made against our present condition in comparing our power then and now is continually forgotten. Captain Mahan has admirably brought out the facts. The supreme position which our Navy occupied during the great war was by no means due to any natural inaptitude on the part of the French for naval operations. During the immediately preceding struggle, we had lost the American Colonies because we had lost the command of the sea. In the beginning of the Revolutionary War the French Fleet had been reduced to complete inefficacy by the disorders in France. After a few feeble attempts to maintain its position under these circumstances in the open sea, it was driven into harbors where it was impossible for it to keep up its fighting efficiency. It it therefore absurd to look upon this as representing in any way the necessary permanent relation between the two Navies.

Among the elements, therefore, of possible future danger with which we ought to reckon, is the undoubted high efficiency of the present French Fleet. To live upon a tradition of the past which shows us everywhere during that particular war inferior numbers of British ships driving before them, or destroying, French fleets, is a dangerous misconception of history. We may hope everything from the skill and valor of our own sailors; we have no right to assume that those qualities will not be found among the French.

Not a few calmly-thinking French sailors believe that the change which has taken place in the nature of ships since 1815 has tended very greatly to the advantage of their own navy. They say, not without much reason, that the direct influence on naval success of the more seafaring character of our population and of the greater hardihood and physical vigor which they frankly attribute to our sailors, was much more certain in those days than now. They consider that a time has come when mechanical skill in construction, and the influence of the engineer, have become far more potent factors than strictly seafaring skill. It is a question on which it is impossible to pronounce without the dire experiment of war. But it is right, in considering the whole of the situation, that British men should realise that that view has to be taken into account.

Furthermore, the development of British free trade has so greatly increased the proportion in which our population depends for food from abroad since those times, that it may be doubted whether in studying Captain Mahan's statement of the case we ought not to allow for the increased pressure that would be put upon us by anything that threatened the sources of our food supply. Considering, however, the way in which that one side of the question has been pressed upon us of late years, it is not a little consolatory to have laid before us, with Captain Mahan's impartiality and as a result of his admirable research, the fact that our enemies early in the great war looked forward with complete confidence to their being able to bring Britain to her knees by attacks upon her commerce alone, even after they had themselves lost the power to contest our supremacy at sea. Captain Mahan has shown clearly that it was the utter failure of this attempt during all the earlier period of the war which made Napoleon face risks, the nature of which he fully realised, in order to prepare for making an actual descent upon our shores.

The development of British commerce has become so enormous that it now presents a much more vulnerable mark to an enemy than it did during the Revolutionary War. We may therefore admit that we are only able to judge from the lesser to the greater, and to treat the experiences of that war as a lesson on a relatively small scale, so far as the immunity of our present commerce from the attacks of petty depredators is concerned. Nevertheless I do not myself believe that any one who will be at the pains to weigh all that Captain Mahan has to urge upon the subject, can fail to realise that his historical evidence has introduced a consideration which has been too much forgotten in the controversies of late years. On the whole, his history tends to show that if we take adequate precautions for the protection of our commerce during war, the percentage of loss which we are likely to incur, though it may be very inconvenient and serious, will not be deadly. Relatively, therefore, this demonstration enchances the importance of the question of invasion; for if attacks upon our commerce will not be decisive of anything, a nation which wishes to crush us will be forced to attempt invasion or to accept a position of great disadvantage. It is therefore necessary to discuss all the more earnestly those conditions which tend to affect the possibility of direct invasion of our shores.

This is very important, because there has been a tendency of te years among some of our naval writers to scoff at the idea our maintaining any "second line of defense" at all. Their gument has been, that if the Navy be supreme upon the seas, ere can be no risk of invasion whatever. If the Navy be not preme then Britain must starve. Now the effect of Captain ahan's work is to show that the process of "starving" Britain ould be, to say the least of it, a very slow and difficult one. On e other hand, despite the changes which have to be taken into count in the conditions of both land and sea fighting, Captain ahan has shown more clearly than it had ever been shown be-re, that the question of succesful invasion was even then a atter of only a very few days of local supremacy for an enemy's eet. What was then necessary to it was not that the supremacy f Britain on the seas should be permanently destroyed, but that uring a given period that sepremacy should not be able to assert self at the right place.*

It may be and it is quite true that had Napoleon succeeded in nding his army upon our coast because there was not sufficient aval force available to resist him, he would still have been liable o find his retreat cut off, and his communications with France evered by the restored supremacy of the British Fleet. It is ot the less obvious that the importance of this fact would depend pon the nature and degree of resistance which his forces might eet with in Britain. If he could so completely sweep away all pposition on land as to dictate terms in London, he felt certain f securing his own retreat. He would have been in no worse a osition in that matter than he found himself in, in Egypt after he battle of the Nile. Despite the loss of all his communications ith France, he was able to effect the capture of Cairo and the omplete conquest of Egypt itself. As the conquest of Egypt roduced no very serious pressure upon the Mistress of the Seas, is failure at Acre made the ultimate abandonment of Egypt nevitable. Britain could at her leisure land forces in Egypt hich would make the position of the French army an impossible ne.

It is, however, important to remember that it was only in this ndirect way that the command of the sea enabled us even to urn the French out of Egypt. It was the actual land-fighting at cre and the success of Sir Ralph Abercromby's expedition at bukir that enforced the withdrawal of the French army. Apply-ng the case to a possible success of Napoleon's in Britain, all the circumstances are reversed—the pressure would be applied directly to the mistress of the very fleet which endangered his retreat. Had the fleet which threatened Napoleon in Egypt been not British but Egyptian, there can be little doubt that Napoleon would have been able to enforce terms which, if they did not actually involve the surrender of the fleet, would have certainly enabled him to open up his own communications with France.

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* These views have been amplified with admirable force in Mahan's *Life of Nelson*.

There is a small school of naval writers who treat it as an insult to our Navy to speak of it as our "first line of defense" and scoff at the idea of there being any use in maintaining our home army, more especially the volunteers and militia. It has happily been repudiated by our most distinguished sailors. No one could have spoken out more strongly on the subject than Sir Geoffrey Hornby did a few years before his death; while Admiral Colomb, who has used expressions that made some of his friends fear that he had committed himself to the views of the school in question, has with equal emphasis repudiated them. It it only, therefore, important to notice the matter in so far as any language of this kind tends to weaken the confidence and zeal of our volunteers, or to furnish a Government with excuses for not supplying them with what is necessary to efficiency.

The difference between Britain maintaining a force at home adequate to resist such an army as could be landed on her shores, and Britain denuded of all home defense—trusting solely to her Navy for protection—is admirably illustrated by the circumstance of Napoleon's expedition to Egypt. If the land force at home were so inadequate that the commander of a hostile army could as completely subdue Britain as, despite the supremacy of our fleet, Napoleon in fact subdued Egypt, the fleet after its first failure to stop the invaders would avail us nothing. If, on the other hand, the invaders were met by a firm and obstinate resistance, terrible as the losses which would be inflicted upon Britain would be, the fate of the invaders would sooner or later be certain, unless the fleet had not only failed us in the hour of invasion, but had permanently lost its supremacy even within the narrow seas. While, therefore, no one can exaggerate the importance, for the safety and the maintenance of the power and the wealth of Britain, of a navy which shall at all times be supreme not only in the narrow seas, but elsewhere, it would be madness to ignore the necessity for an entirely independent system of home defense.

Moreover, as I have often insisted elsewhere, there are avowedly circumstances in the present condition of naval warfare which,

without in the least tending to shake confidence in our retaining our command of the sea if we will make the efforts that are necessary to do so, do make it exceedingly doubtful whether the ablest admiral that we have could guarantee us against a temporary disaster. All sorts of new mechanical forces have come into play since the great war, and no adequate test of their effect has been supplied by recent war experience. I a few years ago publicly put the question at Aldershot to two of our ablest sailors, whether they either of them felt confidence or believed that any one else, whose judgment could be depended upon, did, as to the outcome of the next great naval engagement. Both of them frankly avowed that the complications of the problem were too great for any human foresight. We practically know hardly at all whether the ram, the torpedo, or the big gun are to be the deciding elements of the future warfare. Still less do we know what effect high explosives are likely to produce in naval any more than in land war.

It is said that our best authorities on the subject believe that the difficulties of creating a permanent high explosive have been overcome. That is an element in our favor, the importance of which cannot be overrated. The question involved is so serious a one that, though I have often mentioned it before, I do not think that I ought to omit a full statement for my present readers.

Germany and France both attach so much importance to the effects of high explosive shells that they have spent millions of money upon preparing both to use them and to resist them. Year by year they have continued to store vast materials for the manufacture of these terrible instruments of destruction. France, at all events till lately, made up fresh every year sufficient high explosive material for the loading of all the shells that she will require for a land campaign. I believe she does so still. Germany, in presence of the great array of French fortifications which has been constructed along her frontier, reckons upon the effect of high explosive shells carried into the field for their demolition. Naturally, on a subject which both Governments keep as secret as they possibly can, one cannot always quote the evidence on which one relies for such a statement as this. I am obliged to say this because a certain writer, who shall be nameless, an able man, but one of the least courteous of controversialists, has poured scorn on my words because I have not cited authority for all that I have said. There are times when one can only rely upon the presumption of one's friends that one is not likely either to be a wilful liar or an extremely careless sifter of evidence. I am as certain as I am of my own existence that if I could quote my authorities my critic would change his tune.

There is at all events one evidence of the importance which the German Government attaches to the matter which there has been no attempt to conceal. Under the eyes of any one who has chosen to see it, under my eyes amongst others, they have been piling, around the forts at Metz for instance, at an expenditure which must have been enormous, debris and materials, into the details of which I need not enter, but so designed as to afford protection against the new shells. Those who are willing to believe that an economical Government like that of Germany throws away money in this sort of way, without the most careful preliminary inquiry as to its necessity, are people with whom it is quite useless to argue.

It is said that we have been carrying out a series of experiments with high explosives, and that several years ago we ascertained the fact that one of them, as effective as the rest, would resist the effects of time and change of climate. What is certain is, that very many years ago the question in France and Germany passed out of the stage of experiment and entered into that of practical preparation for war. What is equally certain is, that in a matter in which the preparation for practical use must take many years, we have not advanced one step beyond the experimental stage.

Now when at Aldershot I put publicly to the most distinguished of our admirals* the question, whether he thought it would be possible for a fleet which possessed no shells filled with high explosives to meet another which had a large supply of them, his answer to me was, that of cource when war came we must at all risk put the high explosive shells on board: that is to say, that we are now, in this position, that we have not ventured past the experimental stage in reference to these explosives at all; that none of our sailors have had any training in handling them; and that so serious is the question that we should at the last moment have to make an experiment under the dire circumstances of war, in a matter on which those to whom we should be opposed had already reached the stage of large practice.

If it be true that our own chemists have succeeded in creating an explosive which is not liable to injury either by jolting about in a waggon or by lapse of time, certainly one great disadvantage of the situation has been removed for us. If we are able to store adequate material to have the shells available for issue, and to practise our soldiers and sailors with them, the difficulty involved in the extent of our vast Empire, and the consequent long voyages of our ships, need not trouble us. But at the present moment we are practically in as bad a position as ever, so far as the military use of these terrible new engines of war is concerned. If we have realised their importance, we are like those Athenians who knew what was right, but did not like doing it. If, on the other hand, we are trusting, in the teeth of all the experiments that have been conducted on the Continent, to the results we have obtained at Lydd, then it is necessary to remark that those who have travelled through every country in Europe, to the several experimental grounds of the Great Powers, declare that the investigations which we make on any subject of the kind are so insignificant as compared with those made by others, that they scarcely deserve to be reckoned at all. The wealthiest country in Europe, we skimp the money that is allowed for experiments to an extent that makes only an insignificant fraction of what is allowed by such countries as Austria and Russia. When, therefore, an able man like Sir George Clarke quotes as decisive on this subject "experiments at Lydd," "though it make the unwary laugh, it cannot but make the judicious grieve." Till this question is more satisfactorily settled than it is, we certainly must include among the dangers against which we have to defend ourselves—a possible invasion of Britain.

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* Sir Geoffrey Hornby.

Even if this particular danger be warded off, it illustrates very forcibly the present uncertainties of naval warfare, and the fact that we do not know what changes may arise as a consequence of the progress of invention.

In regard to invasion generally, perhaps the most permanent risk that we run may be most happily expressed in these only too true words of George Eliot's: "The sense of security more frequently springs from habit than from conviction, and for this reason it often subsists after such a change in the conditions as might have been expected to suggest alarm. The lapse of time during which a given event has not happened, is, in the logic of habit, constantly alleged as a reason why the event should never happen, even when the lapse of time is precisely the added condition which makes the event imminent."

To men who, like myself, have had to go on isolated military duty in different parts of the country, these words come home with a force that is partly comic, and partly pathetic. It is tolerably obvious that if there be even a possibility of such a temporary failure of the protection of our fleet, as seems at least to be indicated by the conditions which I have explained, then it is only a matter of common prodence that we soldiers should sometimes consider what the circumstances of actual fighting in this country would be. It does not seem to be an exaggerated precaution that we should examine the positions of greatest advantage for our own army, and should endeavor to obtain such information as would be useful in the event of war at home. As a matter of fact this is, of course, systematically done. The conversations that one is not unfrequently involved in in the course of doing it, with local residents, are very suggestive. George Eliot's words might be taken as the text of most of these.

To not a few isolated spinsters and other nervous persons, the mere fact of soldiers considering the question of home defense at all causes so much alarm and anxiety, that they have to put away from them the unpleasant idea with such sentence as, "Oh, of cource I know it's only make-believe; it never would really happen," and so on. And yet it may be doubted if those good folks realise at all the question, whether "it" ever really will happen, depends almost entirely on the success of their navy, and that again on a House of Commons which laughs at high explosives, just as Belinda laughs at Hell.

As I am only engaged in this chapter in considering the different possible modes of attack upon the country, I pass on now to the dangers which threaten other parts of the Empire.

Among these the first place is neccessarily taken by India. That subject has recently been elaborately discussed in the volume by Sir Charles Dilke and Mr. Spencer Wilkinson, of which a new edition reaches me as these words go to press. It has the defect I ventured to point out in regard to the earlier edition, that it ignores the evidence supplied by Sir A. Haliburton's report. No discussion in regard to our present system can be of much value which does not deal with that evidence. I purpose here to set forth certain general principles which seem to me necessary to be taken into account before their very valuable statement of the condition of the frontier of the Indian Empire can be treated as a practical estimate of our right course in war.

That it is from Russia that we are there liable to attack, just as at home it is from France only that we have any serious reason to anticipate any possible attempt at invasion, scarcely needs to be said. To me it seems now, as it has seemed for years, that what we have to dread from Russia is not so much an immediate invasion of India, as the fact that she is still so remote from India, for purposes of effective action on our part, that she is able continually to make advances which tend very much to increase for her the facilities of ultimate invasion of India, while it is exceedingly difficult for us to interfere with them.

If, for instance, Russia were to choose to seize some of the provinces of Afghanistan beyond the Hindoo Koosh, or were to make up her mind to occupy Herat, it is practically certain that she could do one or the other under the present condition of things before we could interfere with her. Suppose that she did either one or the other, and remained, without further eggression, in tranquil possession of them, we should be, under present circumstances, placed in a position of the very greatest difficulty.

We have given such pledges to the Ameer that we could not, without violation of the honor of our Goverment, refuse to assist the Ameer if he called upon us to aid him in recovering them. In a military sense that would involve us in a campain, not only in itself arduous, but such that we should put ourselves at a great disadvantage as compared with Russia. The march of our troops, all reinforcements for them, their connection with India, and the supplies of food and ammunition that they would require, must run through most difficult country, in which a few hostile tribes acting against them might place us in an awkward position, if not in imminent danger. The mere fact that we entered as allies of the Ameer would not at all secure us against the predatory instincts of banditti nominally under his rule. Any disaster, almost any rumor of disaster, that happened to our troops, in the distant province which we should have to enter in order to fulfil our pledges, would certainly cause the most fierce attacks upon our lines of communication, and make the efficient maintenance of the force at the front a task extraordinarily hard.

Nor can I see what security we should have, even after we had expelled the Russians, that as soon as we went home again they would not immediately re-enter into possession. The occupation of Cabul and Candahar, which is talked of as the necessary consequence of any such action on the part of Russia, would surely not satisfy the Ameer as a fulfilment of our pledge to defend his territory whether beyond the Hindoo Koosh or otherwise.

Yet the alternative is a most difficult one. If we violate our pledges to the Ameer, not only shall we make him a tool in the hands of Russia, but we shall shake all confidence in our word throughout the East. We shall manifestly have promised to do that which we were not able to do, and have recoiled because of sheer impotence. Furthermore, though perhaps our interest in the territory beyond the Hindoo Koosh is small, on any other ground than that of our pledge to the Ameer, our interest in Herat is very large. In its present condition Herat is probably of little importance to anybody. Developed as it might easily be, and almost certainly would be, for military purposes under Russian rule, it would become, what it always used to be in former ages, the gate of India.

The practical meaning of that figurative phrase is easily explained. The first necessity that has to be secured for Russian action anywhere, but more especially on the confines of India and throughout Asia, is facility of movement and of transport. It is obviously not enough that there should be, somewhere or other, under the command of the Czar untold millions of soldiers. In order that they may effect anything on the confines of India, those that are to fight must be near enough to shoot, and have with them both the means of shooting and the means of living. At very great sacrifice the Russians have carried their railway from the Caspian along the northern frontiers of Persia and of Afghanistan. But the railway is necessarily one along which the transport is slow, and it offers no facilities for the further movement across Afghanistan upon India. If Herat were in the hands of Russia and its military resources fully developed, most of the implements of warfare could be constructed within the province itself. Large supplies of food also for an army could be grown there, and in the settled province large stores also of such things as an army would require, such as could not be procured in the place, could be gradually accumulated. When the process was complete, the change in the situation would in fact be that a Russian army would have to advance either upon Afghanistan, or upon India, from Herat, and would draw all its supplies from it. All the difficulties of the long transport across the Caspian by the narrow-gauge railway, and thence over the roads where there is at present no railway, would be overcome. The position of advantage in which Russia would stand under these circumstances, must, I think, be intelligible to any one even if he has very little considered the nature of military operations.

To sum up, therefore, the case, as it appears to me, stands thus. Supposing that Russia carries on consistently the policy that she has been following for years, she, being nearer both to Herat and the provinces north of the Hindoo Koosh than we are, can occupy them whenever she is not afraid of a general war with ts. We could only turn her out of them at very great cost, with ery great difficulty, and with very great risk. To me, therefore, seems, as it has always seemed, that our true policy is to revent her from making this attack upon us by taking advantage f the general political situation of Europe. How that can best e done, it will be the object of a future chapter to show. My resent purpose is to indicate the fact that the form of attack hich we have most to dread from Russia on our Indian frontier not an immediate invasion of our Indian provinces, but such a radual advance into positions of future advantage for her, as it ill be exceedingly difficult for us to stop by direct action in India.

In two other quarters, other than in Afghanistan, there is enace of this danger. The recent advance of Russia into the amirs has attracted much attention ; her stealthy inroads upon ersia very little. Nevertheless, I am myself inclined to think at the Persian question is much the more serious of the two. few years ago, when Baker Pasha and Sir Charles MacGregor isited the northern frontier of Persia, it was still possible to ake a serious impression from that side upon the line of comunication of Russia between Merve and the Caspian.

But Russia has been steadily guarding herself against that anger, and, taking advantage of the feebleness of Persia, has stablished herself in such a way that practically the opportunity or us is closed. We now, at Chitral, watch the approach from he Pamirs, and on that side, considering the nature of the region, o not seem to have much to fear.

Our various Colonies are most of them exposed to certain risks f their own. A few years ago Russia had designed an attack pon the Australian Colonies from her Pacific harbor of Vladivotock. It was intended that a fleet should sail upon the then open owns of Australia, harass them, and excact fines from them. he wisest advisers of the Colonies have of late years been nxious to restrain them from expending too much money upon efensive works. The defense of a great island like Australia ust depend primarily upon the efficiency of the fleet, and econdly upon the careful organisation of the defensive forces n land. For a time the effect of the certainty of Russia's intenion was to infuse such a vigor into the system of Australian deense that all danger of any such attempt seemed to have passed way. But there is always risk lest a democratic community shall o to sleep as soon as the immediate alarm has passed, and wake hen it is too late.*

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* I must draw attention to a volume on the *Federal Defense of Australasia*, by George athcart Craig (William Clowes and Son, 1897). It reaches me too late for notice here, but

There is a special form of attack which may be directed against those possessions of England beyond seas, which are, to say the least, less important as colonies than as outlying posts for the protection of the commerce of the mother-country, and of the Empire at large. This expression applies more particularly to our fortified coaling-stations. These have now so far advanced that it is to be hoped that before we are involved in war they will be completed, armed, and garrisoned so far as to fulfil the purpose for which they were intended. That purpose will be understood when I have explained the form of attack which a few years ago we had to dread. It was one directed expressly against the supplies of coal on which alike our fleet and our commerce depend for possibility of movement.

The fear which was felt by those who looked into the circumstances of any future naval warfare, was lest an enemy's cruiser might go into one of our unarmed coaling-stations, fill up her bunkers with coal, and, after setting fire to the remaining store in the place, proceed at her leisure to destroy commerce, having protected herself from pursuit by the destruction of the coal. She might then repeat the same operation at one coaling-station after another. Admiral Colomb has devoted much labor and skill to the demonstration of the fact that the elaborate fortification of harbors is a wasteful expenditure. He has shown that the question of supremacy at sea must necessarily be determined, not by land fortifications, but by naval superiority. These views have so far ruled in the construction of our coaling-station defenses, that no attempt has been made to make them strong enough to resist the attack of a formidable fleet. No one more fully than Admiral Colomb himself recognises the importance of those steps that we have actually taken to secure our supply of coal from the attack of ubiquitous cruisers.

The subject gained additional interest by the publication in Russia, some years since, of the little brochure, *Russia's Hope*, which was based upon this very idea, evidently stolen from some of our English authors, probably from my friend Colonel Home, at the time when, many years ago, he and others[*] were pressing for the defense of the coaling-stations. *Russia's Hope* would nowadays find that form of attack somewhat difficult. No protection that we have been able to devise, either in the past or the

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it admirably shows that there are Australians who are determined that our great Australasian colonies shall not sleep tranquilly in imaginary security, or foolishly dream that separation from Britain would make them safer or freer.

[*] Ultimately most vigorously of all Mr. W. H. Smith and Lord Carnorvon. See the excellent collection of Lord Carnarvon's speeches and letters on the subject, recently edited by Sir George Clarke, *The Defense of the Empire* (John Murray, 1897).

present, unless and until the whole of our enemy's fleets are securely locked up in their own harbors, can prevent an occasionally successful attack by a fleet escorting a land force against some isolated port. Ultimately, however, the fate of any of these will depend upon victory at sea. Beyond their local importance such attacks would have very little effect upon the general security of our commerce, except in so far as by the capture of one of our coaling-stations they broke some one of the great lines of these which have now been regularly laid out along the several courses of the great streams of our commerce at regulated intervals. Thus along the line to the Cape we have St. Helena and Sierra Leone, thence to India, Durban, Mauritius, Colombo, and our other lines are similarly laid out.

The capture of any one of these stations would, of course, interrupt for the time the regular coaling of our ships. That, therefore, is another of the forms of attack against which we have to be prepared.

It is unfortunately the case that there are various stations very necessary for the security of our trade where we are liable to attack from a different enemy, namely, malaria. It is always a question whether we ought not to provide against it, even at some sacrifice of our preparedness against a human foe. It is on this account that there have, till recently, been among our troops at home certain detachments which are noted as belonging to the proper garrison of certain unhealthy stations like Sierra Leone; for the moment of the outbreak of war these stations would have been left to the guardianship of the fleet. As soon as possible their proper garrisons were to have been sent out to them. As, however, the Admiralty might find it very difficult to secure due protection on the outbreak of war, it has recently been decided to have complete garrisons everywhere.

Similarly St. Lucia is an island of which the importance, from its excellent harbor and convenient situation, makes it most desirable to have as a defended coaling-station; yet it was considered too unhealthy for a permanent garrison to be maintained at its full strength. A large portion of its garrison was therefore to be sent from Barbados when the emergency arose. This, however, has now been changed, and, with such sanitary precautions as are possible, a garrison is now to be kept at St. Lucia.

So far as Canada is concerned, apart from any calamity so terrible as that of a war with our cousins in the States, there is always some danger during time of war of filibustering attempts being made from the United States against various points, and especially against the long line of the Canadian Railvay. Sir Charles Dilke, who has studied all such matters very carefully, attaches very great importance to these. Personally, I cannot say that any experience we have had of them in the past leaves that impression upon me. I could, if I pleased, which I certainly do not propose to do, name what I have always considered a weak point in our defensive arrangements on the American Continent. There is a point where a well-handled body of filibusters might achieve a rather startling success. But I do not think that, as long as the American Government proves as loyal as it has hitherto done in such matters, and as long as Fenian filibusters have so little power of keeping a secret, or of acting loyally towards one another, as they have hitherto shown, there is any serious danger for us of this kind. Canadian statesmen, who necessarily have had to look into the matter more closely than Sir Charles Dilke, have the most complete confidence in the security for all practical purposes of the great trans-continental line.

Though, in order to make myself intelligible, it has been necessary occasionally to allude, especially in regard to minor matters which need only brief treatment, to some points in the nature of the defense which we should have to adopt against certain possible forms of attack, my object in this chapter has been to consider the form of the various attacks which may be directed against the nation in different parts of the world. These may be enumerated thus:—

First of all, attacks upon our commerce by means of cruisers or fleets.

Secondly, an attempt to wrest from us the command of the sea, either permanently or temporarily.

Third, attacks upon open towns along our sea-board.

Fourth, attempted invasion either of this island or of Ireland by sea.

Fifth, if a Channel tunnel should ever be constructed, an attempt to seize, by surprise or otherwise, the means prepared for its destruction and the fortress which guards them.

Sixth, aggressive movements of Russia, preparatory to attack upon India itself.

Seventh. the actual attempt of Russia to invade India.

Eighth, attempts upon our Colonies other than coaling-stations.

Ninth, attempts upon our coaling-stations in the form of a cruiser attack upon the coal itself without any attempt to seize the station itself.

Tenth, attack by a serious force on a coaling-station with a view to occupy it either permanently or during the period of the war.

Eleventh, a mere predatory raid, such at that intended by Russia from Vladivostock, upon Australia.

Twelfth, filibustering raids from America upon Canada.

In addition to all of these forms of attack, which relate to the possible action of hostile European Powers, there is that which, in its practical effect in necessitating preparation and expenditure, exceeds them all—the danger, on the outlying frontiers of our Empire, of hostile incursions by neighboring tribes. It constantly happens that British people assume that whenever an Ashantee King or a Zanzibar Sultan defies the power of the British Empire the thing is so absurd that it must be the fault of our own people that he does not yield to reason. They do not realise how one of these chiefs, surrounded by flatterers as ignorant as himself, really believes all the titles that are bestowed on him, as King of Kings, Lord of the Universe, and the like, and has not the slightest means of estimating his own feebleness. Therefore, also, as war and not peace is for him and his people the natural condition, he habitually assumes an attitude of aggression, which is encouraged by the fact that every one who has to carry on negotiations for Britain—in any matter as to which the British people have not become exited and eager—wants before all things to avoid doing anything that can commit the nation to war. Constantly, in this way, a savage chief is thus tempted, by his own aggressiveness and our passivity, into just overstepping the line of what it is possible for us to tolerate. Then war comes, and half Britain thinks that it is all our fault, and attributes the cause to just the opposite of that to which a fair study of the facts leads.

All these possible forms of attack taken together, provided our Fleet be supreme upon the seas, do not represent a danger as serious as that which menaces Germany or France; but they do represent a necessary dispersion of force, dispersion of design in the nature of the defense, a vast number of independent local authorities in proportion to the number of men employed, and a consequent costliness which cannot but appear to compare unfavorably, no matter what schemes be devised for it, with the larger, the simpler, the more concentrated efforts of foreign countries. I am anxious to emphasise this broad aspect of the case. I wish to do so for this reason: I am convinced that it is a pure and mere delusion, most costly, most mischievous in its effects, to attempt to persuade the British public that they can hold a world-wide empire, hold the commerce of the seas, do it at a *pro rata* proportion of their wealth, utterly insignificant as compared with that which any European Power expends on guarding their own little territory, and then allow themselves to be persuaded that all the time they are being bamboozled into a wasteful and useless expenditure. I say that it is on these broad lines that one may appeal to the common sense of any rational man to judge for himself.

Sir Charles Dilke once said that directly the attempt is made to go into detail it is extremely difficult for him, or any non-military statesman, seeking for particular items of wasteful expenditure, to answer the case made for them by soldiers. He speaks, in the first instance, as though it were the special interest of individual soldiers to defend extravagance. The fact is that the exact reverse is the case. If I, in any matter under my own responsibility, could detect some means by which the work could be done just a little cheaper than it actually is done, I should be an imbecile of the first water if I did not realise that in my own interest the first thing I had to do was to point this out. So deeply is this impressed on the minds of soldiers that I cannot remember ever to have seen a scheme of reform suggested by a soldier in which it was not proved, to the satisfaction of the writer at all events, that his proposals would lead to some, at least, trifling reduction of expenditure. The soldier in Britain who does not realise that the easiest way to secure his personal advancement is not to make £10,000 produce twice the effective work that it has done before, but to show that the same appearance of efficiency may be kept up for £9999:19:11¾, simply does not understand British finance. Soldiers may be great fools, but they are not quite so blind as all that.

To put money in his own pocket by securing positions of much greater importance than he at the time holds, this method of seeking out some apparent economy might be commended to any soldier in a sufficient position to practice it. It needs not to be so commended. It is thoroughly understood, and much practised.

There is an even better method, which has stood some men in excellent stead. It consists in proving, on excellent military grounds, that for the sake of efficiency it is highly necessary to carry out some petty military economy. By such methods the individual gains both in credit and pocket. It is the nation only that suffers.

The officer, therefore, who points out, on grounds that all men can understand, that it is not advisable to be perpetually recasting your whole system—because it can be shown that Germany or that France is able, for the same sum of money that we expend, to turn out an incomparably larger body of men than we do—ought not to have his argument suspected or rejected on *prima facie* grounds, because from his position he is necessarily suspected. The balance of presumption is altogether the other ay.

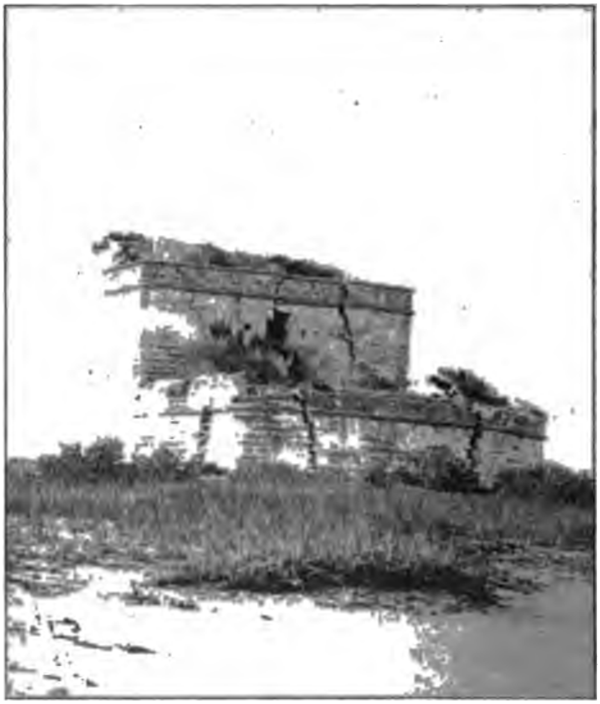
It is not in this chapter that I can fully state the conclusions to which these remarks lead; but, in making out a statement of the variety of the attacks to which the world-wide extent of our empire on sea and land lays us open, it seems well to draw attention at once to the broad presumption to which they lead. It is in no wise my intention to contend that our system admits of no improvement, and that no waste occurs. For many reasons much waste occurs, and ought to be remedied; but the comparison often made with the armies of foreign Power is an altogether fallacious one, and tends not to economy, but to mischief.

HISTORY OF THE SEA-COAST FORTIFICATIONS OF THE UNITED STATES.

IV. OLD FORT MATANZAS.

Immediately in front of St. Augustine lies the northern end of Anastasia Island. This island stretching southward for seventeen miles terminates in a point called Matanzas—a name also given to the tide stream separating Anastasia from the mainlan

Few visitors to St. Augustine take the trouble to visit Matan and yet it is well worthy of a visit. It was here that in 1 Menendez, the founder of St. Augustine, slaughtered several hundred Huguenots wrecked on the coast near by. To this day human bones are sometimes exposed on the spot assigned by tradition as the scene of the slaughter. Only a few miles below Matanzas lies the original settlement of the so-called Minorcans, the ancestors of the present "native" population of St. Augustine.



Moreover, Matanzas was an important point in the attempt made by Governor Oglethorpe, of Georgia, to conquer the Spanish colony. This led the Spanish to fortify it, and the work they built forms today one of the most interesting ruins in our country.

It can be a question of only a few years, or of perhaps a storm of unusual severity, before this ruin will crumble completely to pieces. The writer accordingly, in 1886, spent several days in making complete measurements of the fort, with a view to securing some record before the final demolition took place.

Before, however, proceeding with the description that forms the subject of this paper, it may not be amiss to describe briefly he circumstances and reasons that led the Spanish Government o fortify Matanzas Point as it did, for at first sight the construcion of a costly stone fort in a wilderness appears to be an aburdity.

The adjacent inlet is now but a shallow break in the chain of andy islands skirting the east coast of Florida. According to radition however, in the days of the Spanish dominion, the inlet was deep enough to admit the free passage of vessels, and communication with Havana was established through it. St. Augustine, we know, was hedged about by lines of vallation and circumvallation. It was protected not only by the great four-bastioned fort standing opposite the harbor entrance, but also by a long stockaded eartwork on its north, and by bastions on the west and south. But these last were of feeble profile. A determined enemy holding Matanzas River might turn, and so make useless the main line of defense stretching across the front of he city from Fort San Marco to the San Sebestian River. Hence, n any plan of defense, it was necessary to control the Matanzas, as well as to protect the front of the city. That these obvious conditions of military security should have escaped notice is not likely, and it is therefore more than probable that some defensive work always existed near the southern mouth of the Matanzas.

The local histories, it is true, state that this mouth was fortified only after Oglethorpe withdrew his blockading vessel therefrom. But this view, apart from its inherent improbability, is not confirmed by the statements of a quaint old geographer of the eighteenth century. He first describes St. Augustine itself: "The City runs along the shore at the bottom of a pleasant hill shaded with trees in the form of an oblong square being divided into four regular streets, which cut each other at right angles." And then he goes on to say: "About seven Leagues below the

Fort of *St. Augustine* are two Forts, the one on the north, and the other on the south side of a large lake. General Oglethorp destroyed the last, and took possession of the first, which is called Mauchicolis, surrounded with strong Palisadoes about eight foot high, with loopholes about seven foot high from the ground without; and within there is a Parapet, near three foot high, which makes the loopholes about breast high."[*]

The truth probably then is, that Matanzas was always protected by defensive works of some sort, and that after Oglethorpe's exploits, the Spanish Government resolved to make similar ones in the future, extremely difficult if not impossible, by constructing a work that would not only thoroughly defend the channel, but also successfully withstand a siege. Otherwise, it is hard to imagine why a fortification relatively so strong should have been built in what was then, and has been until lately, almost a wilderness.

In order to appreciate the advantages of the spot selected, it is necessary to understand that the Matanzas River, so-called, is really a narrow tide-water stream, lying, as has already been said, between Anastasia Island and the mainland, and communicating with the ocean at St. Augustine and Matanzas. As it nears the latter place the stream widens and its channel is divided into two by a series of low marshy islands, or rather islets; these passed, it reunites its branches and continues on its way about a mile to the ocean.[†] The southernmost of these islets forms the site of the fort. From this point its guns could be laid on both channels. It was safe from close attack by ship on account of the shallowness of the waters, and, for the same reason, it was out of range from the ocean. Being completely surrounded by water, it would be tolerably secure against surprise by either Indians or English. It is evident from these conditions that the fort was in all probability more than an adequate defense against any forces that might be brought against it, and would thus satisfy the purposes that led to its construction. Let us now briefly examine the work itself.

Standing as it does on the eastern shore of the islet mentioned, its general appearance is that of a broad, low platform, from the north side of which rises a narrow rectangular building. The material of which it is built is the coquina stone quarried on Anastasia, cut into regular blocks, and laid in regular courses.

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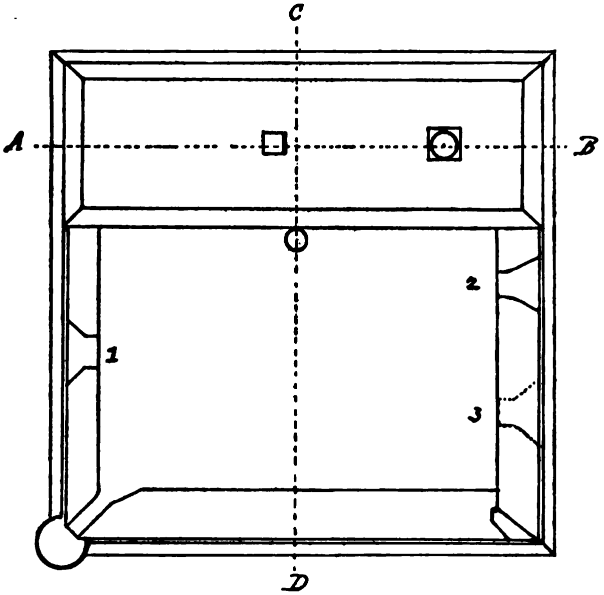
[*] "A Complete System of Geography, by Emanuel Bowen, Geographer to his Majesty. For the use of all Gentlemen Mariners and others, who delight in History and Geography. London MDCCXLII." Vol. II, p. 365.

[†] For the map accompanying this paper I am indebted to Captain G. J. Fiebeger, Corps of Engineers, U. S. A., now professor of Engineering at the U. S. Military Academy.

The whole structure was once covered by white stucco, patches of which still stick on in defiance of the elements. It is now a ruin ; deep cracks split it from top to bottom ; the corners of the platform are slowly but surely crumbling away. Parapets and embrasures have lost their regularity of outline, while scrub cedars and other thick scrubs have sprouted and grown wherever their roots could lay hold.

FIGURE I.



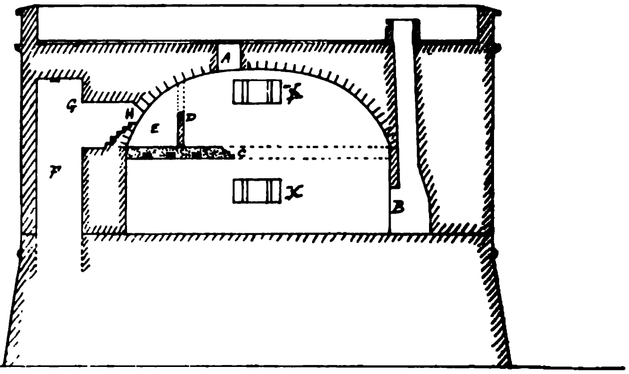
PLAN—Scale 1 : 169.7

1, 2, 3, embrasures (3 almost completely crumbled out of recognition, and hence drawn dotted, its dimensions taken from 2).

The platform mentioned above consists of a block of solid masonry 49′ 6″ square at the base, and 10′ 5″ high. Its walls are not perpendicular, but slope in at the rate of about 1′ 6″ in 10′. The top of the slope is finished off by a cornice running completely around. From this cornice the walls and parapet rise perpendicularly. This block is laid in ten courses, and is pierced by neither window nor door, all access being by means of ladders —a disposition adding to the safety of the garrison and giving at the same time a certain degree of command to the guns. Time has simplified the entrance for us however, as a deep crack in the west front allows us to creep under the parapet into the work. On the north side, and running completely across the platform, stands the building already mentioned. This formed the barracks for the garrison, while the remaining space, 40′ by 25′ 7″, constituted the gun platform, surrounded on three sides by a parapet, the barracks forming the fourth. This parapet is 4' thick on the east, 4' 9" on the south and 3' on the west. It is, or was, pierced by two embrasures on the sea-, and by one on the land-side, while over the remaining one the guns were mounted *en barbette*. For this reason, this portion of the parapet is somewhat lower than the remainder, being considerably less than 3', as against 3' 3" on the east and west. Through the southwest corner a passage-way 21" wide leads to a circular sentrybox, 3' in diameter, all but the base of which has completely crumbled away. The floor of the platform was once smooth concrete. Two old iron guns still lie on it, their carriages having disappeared long ago. The great age of these guns is attested by the fact that the axis of the trunnions is not in the same plane with that of the bore. Half way between the end parapets, and immediately under the walls of the barracks, a circular hole 2' in diameter opens into a cistern holding the water supply of the garrison. It is 13' deep and 9' 7" in diameter to a height of 5' 3" from the bottom. This portion is built of hard brick. The neck of the cistern is 4' 2" long and joined to the part built of brick by a dome of coquina blocks cut and fitted with the utmost nicety to form a hemispherical surface.

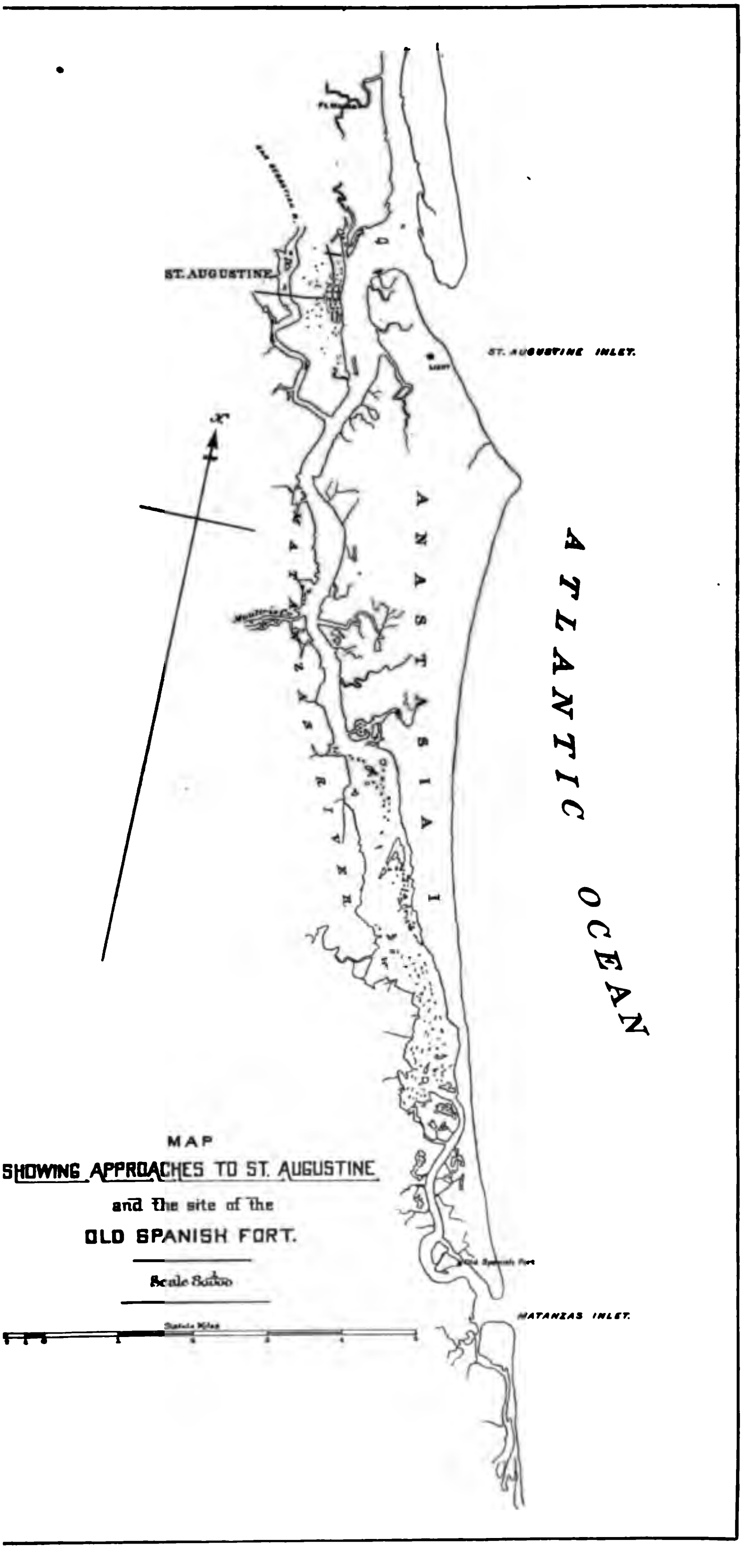
The most interesting part of the whole work, however, is that I have called the barracks. Externally these are 46' 10" long & 15' 7" wide and 21' high. At a height of a little over 17' a cornice surrounds the building. The walls are carried 3' 3" above the cornice so as to form a parapet to the flat roof, thus increasing

FIGURE 2.



SECTION ON A B—Scale 1 : 169.7.

C, flooring of concrete. B, chimney. A, hole communicating with roof. H, hole in face of arch communicating with well. F. XX, windows.

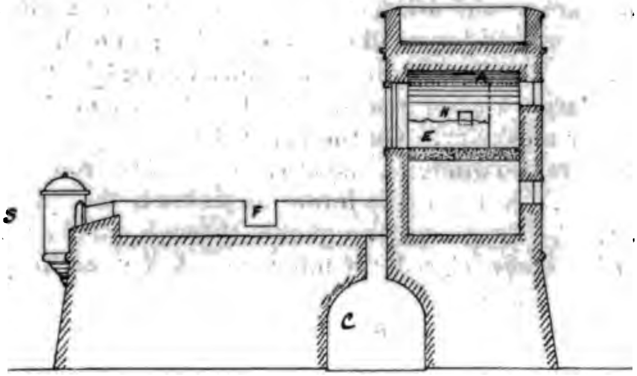


MAP
SHOWING APPROACHES TO ST. AUGUSTINE
and the site of the
OLD SPANISH FORT.

Scale $\frac{1}{80000}$

the offensive power of the work. In this flat roof we may recognize a feature of Spanish architecture, applied in this case to military purposes. Entering through a low door-way, on the right of the cistern just described, we find ourselves in a large arched room, the distance from the crown of the arch to the floor being 15′ 7″, and between springing lines 27′. The surface of the arch is plastered over, and still shows traces of the bright blue color with which it was once washed. The interior arrangement of this room will be best understood by following the sections, Figs. 2 and 3. Near the highest point A is a rectangular hole 25″ by 26″, designed both to furnish ventilation and to give access to the roof. The eastern end is filled by a large stone fireplace, B, now almost completely dismantled. The whole interior space was in former times divided into an upper and a lower room by a platform shown in section at C. Part of this platform still remains at the western end, and is of singular construction, being made of wooden beams, running across, between and over which rests a concrete floor over one foot thick. Its supporting ability depended on the thickness, and consequent rigidity, of the concrete. As lumber must have been plentiful and easily obtained, it is hard to see why so cumbrous and essentially weak a flooring should have been thought necessary. The western end of this room is cut off from the remainder by a stone wall D once running up to the arch, and now half torn down. A door-way through this leads into a kind of closet or cell E, from which a

FIGURE 3.

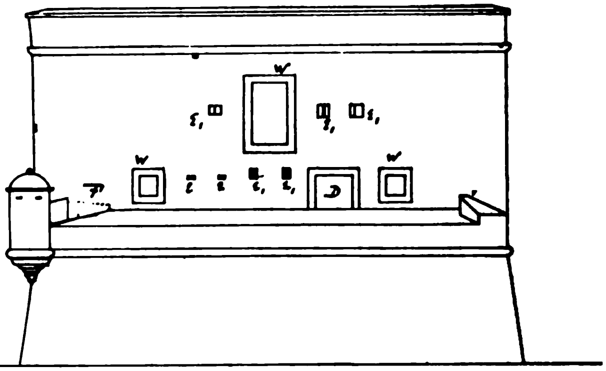


SECTION ON CD—Scale 1 : 169.7.

C, cistern. H, hole in face of arch communicating with well. E, partition wall—once running up to dotted line below A. The sentry-box S, is a restoration. A, hole communicating with roof. F, embrasure in west parapet.

hole 15″ square cut in the surface of the arch communicates by a flight of steps and a short passage with a circular well F, 4′ 3″ in diameter, and extending both up and down. This well is built in the thickness of the western wall and extends 2′ 3″ above the point G; its depth could not be determined, as it is partly filled with stones and rubbish. The use to which this well, as I have called it, could have been put, has given rise to much conjecture. In accordance with the custom prevailing in St. Augustine in similar cases, some consider it a prison cell connected with some dark mystery or evil design. But it is probably nothing worse than the powder magazine of the fort, an inference that may be fairly drawn from the care evidently taken to separate it from the remainder of the quarters. Into each of the rooms into which the arched space was divided, light and air were admitted by windows, there being a small one to each in the north wall. On the south the number is greater. Thus we find in the upper room one large window reaching to the floor, and flanked by loopholes for musketry. On the lower floor, in addition to the door, there are two windows, one at each end of the room, besides two loopholes. Nor must we forget to mention the queer little peepholes, 1″.5 by 3″, on the inside, through which, when all other openings were closed, the inlet and adjacent territory could be reconnoitred. Doors and windows both have plate-bands instead of lintels. The side walls of the building are 25″ thick; the end ones, forming the abutments of the arch, 10′. The space between the arch and the roof has been filled in solid, giving the arch an entirely unnecessary weight to support, and one that will

FIGURE 4.



ELEVATION OF SOUTH FRONT.—Scale 1 : 169.7.

F, restoration showing how south parapet was probably connected with sentry-box. $e_1 e_1$, loop-holes. e e, peep-holes (sentry-box restored). D, door. w, w, w, windows.

eventually cause the complete demolition of the building. It thus contains within itself the source of its own destruction. Even now a huge crack runs from top to bottom along the surfaces of weakness determined by putting the windows along the rise of the arch; while a second ever-widening crack almost completely separates the eastern abutment from the remainder of the building. The insecure foundations, unavoidable in so marshy a situation, are of course partly responsible for these fissures, but they should have warned the architect against loading the arch so severely.*

In examining this ruin, one cannot but be struck by the care displayed in the elaboration of details, some unimportant in themselves, and others made unnecessary in this particular fortification, both by its situation and the purpose it was intended to fulfill. As examples of this care, may be mentioned the cornices, the bevelled door- and window-jambs, the plate-bands and sills, all standing out in relief; the carved base of the sentry-box, and the mathematically accurate surfaces of the magazine and cistern. The great resemblance between these and corresponding details at Fort Marion inspires the belief, in the absence of other evidence, that the engineers who brought this last fortification to completion, designed and built the other. The date of erection of Fort Matanzas would thus be between 1740 and 1756.

In bringing this article to a close, we cannot help expressing a natural regret that our Government should have suffered the work here described to fall into its present ruinous condition. When the "change of flags" took place in 1821, it was probably in a fair state of preservation; it is now almost past saving. A little care and attention, a small outlay of money at the right time, would have preserved intact for years to come one of the most interesting monuments of our country—a memorial, to us, of the earnestness with which Spain strove to maintain her hold upon our land.

First Lieutenant C. de W. WILLCOX,
Second Artillery.

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* The sheet-piling by which the foundations were strenghtened has not yet entirely disappeared.

◆

BALLISTIC PROBLEMS IN INDIRECT AND CURVED FIRE.

It is generally admitted by writers on ballistics that the quadratic law of resistance holds for all velocities below 800 f. s.,[*] which includes nearly all firing with mortars and mountain howitzers and also the indirect fire of field and siege guns. The following formulas with the accompanying table have been prepared for these kinds of fire.

The fundamental equations employed in Siacci's method for direct fire are[†]

$$x = C\left\{S(u) - S(V)\right\} \tag{1}$$

$$y = x \tan\varphi - \frac{Cx}{2\cos^2\varphi}\left\{\frac{A(u)-A(V)}{S(u)-S(V)} - I(V)\right\} \tag{2}$$

$$\tan\theta = \tan\varphi - \frac{C}{2\cos^2\varphi}\left\{I(u)-I(V)\right\} \tag{3}$$

$$t = C\sec\varphi\left\{T(u)-T(V)\right\} \tag{4}$$

$$u = v\cos\theta\sec\varphi \tag{5}$$

$$C = \frac{\delta_1 w}{\delta\, c d^2} \tag{6}$$

Siacci considers these equations practically correct for all values of φ up to 20°[‡].

For the entire horizontal range these equations become[§]

$$X = C\left\{S(u) - S(V)\right\} \tag{7}$$

$$\sin 2\varphi = C\left\{\frac{A(u)-A(V)}{S(u)-S(V)} - I(V)\right\} \tag{8}$$

$$\tan\omega = \frac{C}{2\cos^2\varphi}\left\{I(u) - \frac{A(u)-A(V)}{S(u)-S(V)}\right\} \tag{9}$$

$$T = C\sec\varphi\left\{T(u)-T(V)\right\} \tag{10}$$

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[*] Siacci, *Balistique*, French edition, 1892, page 84. La Llave, ***Balistica Abreviada***, **1893, page** 77. Zaboudski, *Exterior Ballistics*, (in Russian) 1895, page 55. ***The Bashforth Chronograph***, 1890, page 138.

[†] *Handbook*. Introduction and Appendix 1.

[‡] *Rivista d 'Artiglieria e Genio* for February, 1896.

[§] For convenience of printing the letters *u* and *v* will refer to the **far end of any arc under** consideration. The conditions of the problem will always indicate **what arc is meant.**

$$u = v \cos \omega \sec \varphi \tag{11}$$

Mayevski's modification of these formulas for high angle fire, employing Didion's α, will be found in the Handbook, Appendix 2. It was intended at first to employ these modified equations in this paper for angles of departure lying between 15° and 30°, as being more accurate than any others known to the writer. But Siacci's paper "Nuova tavola della funzione β"[†] was received from the author in time to be used instead. By means of these functions or factors, applied to the ballistic coefficient, Siacci's formulas for direct fire are rendered equally applicable to high angle fire, with an immense saving of labor and no sacrifice of accuracy, as very searching tests have proven.

If, as first suggested by Braccialini,[*] we make the following substitutions, namely.

$$z = S(u) - S(V)$$

$$A = \frac{A(u) - A(V)}{S(u) - S(V)} - I(V)$$

$$B = I(u) - \frac{A(u) - A(V)}{S(u) - S(V)}$$

$$A' = A + B = I(u) - I(V)$$

$$B' = B/A$$

$$T' = T(u) - T(V),$$

equations (7), (8), (9) and (10) become, respectively,

$$X = Cz \tag{12}$$

$$\sin 2\varphi = AC \tag{13}$$

$$\tan \omega = \frac{BC}{2 \cos^2 \varphi} = B' \tan \varphi \tag{14}$$

$$T = C T' \sec \varphi \tag{15}$$

Equation (14) may also be written, when the ratio $\cos \varphi / \cos \omega$ is approximately unity,

$$\sin 2\omega = BC. \tag{16}$$

We have also introduced the following auxiliary functions into our table:

$$A'' = \frac{Bz}{A'} = \frac{y_0}{C \tan \varphi} \qquad C' = \frac{A}{z} = \frac{\sin 2\varphi}{X} \left(\frac{V}{800} \right)^2$$

$$C'' = \frac{A}{2T'} = \frac{V \sin \varphi}{800 T} \qquad C''' = \frac{Az}{T'^2} = \frac{2 X \tan \varphi}{T'^2}$$

[†] For a brief outline of the method of using this function see *Handbook*. Page 296.

[*] *Giornale d'Artiglieria e Genio*. Part 2, 1883.

Their uses will be shown in the proper problems.

For the quadratic law of resistance the ballistic functions $S(u)$, $A(u)$, $I(u)$, $T(u)$ take the following forms:*

$$S(u) = -\frac{\log_e u}{A_1} + Q_s$$

$$I(u) = \frac{g}{A_1 u^2} + Q_i$$

$$A(u) = \frac{g}{2 A_1^2 u^2} - \frac{Q_i}{A_1} \log_e u + Q_a$$

$$T(u) = \frac{1}{A_1 u} + Q_t$$

in which A_1 is an experimental constant determined by Mayevski from a discussion of the Krupp firings,† and whose value for English units is $[5.6698914-10]$.

Q_s, Q_i, Q_a, Q_t are constants of integration. Substituting these values in the expressions for z, A, A', B and T' they become by easy reductions

$$z = \frac{1}{A_1} \log_e \left(\frac{V}{u}\right) \tag{17}$$

$$A = \frac{g}{2 A_1^2 z}\left(\frac{1}{u^2} - \frac{1}{V^2}\right) - \frac{g}{A_1 V^2} \tag{18}$$

$$B = \frac{g}{A_1 u^2} - \frac{g}{2 A_1^2 z}\left(\frac{1}{u^2} - \frac{1}{V^2}\right) \tag{19}$$

$$A' = \frac{g}{A_1}\left(\frac{1}{u^2} - \frac{1}{V^2}\right) \tag{20}$$

$$T' = \frac{1}{A_1}\left(\frac{1}{u} - \frac{1}{V}\right) \tag{21}$$

These equations may also be expressed exponentially as follows: Making

$$2 A_1 z = n$$

equation (17) gives

$$\frac{1}{u} = \frac{e^{\frac{1}{2}n}}{V}$$

and

$$\frac{1}{u^2} = \frac{e^n}{V^2}$$

and these values substituted in (18), (19), (20), (21) give

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[*] *Handbook.* Pages 271-274.

[†] *Revue d'Artillerie*, April, 1883. Ingalls' *Exterior Ballistics.* Page [illegible]. Zaboudski's *Exterior Ballistics* (in Russian). Page 55.

$$A = \frac{g}{A_1 V^2}\left(\frac{e^n - 1}{n} - 1\right) \tag{22}$$

$$B = \frac{g}{A_1 V^2}\left(e^n - \frac{e^n - 1}{n}\right) \tag{23}$$

$$A' = \frac{g}{A_1 V^2}\left(e^n - 1\right) \tag{24}$$

$$T' = \frac{1}{A_1 V}\left(e^{\frac{1}{2}n} - 1\right) \tag{25}$$

Also

$$u = \frac{V}{e^{\frac{1}{2}n}} \tag{26}$$

By division we have

$$\frac{B}{A} = B' = \frac{1-(1-n)e^n}{e^n - n - 1}$$

The factor B' is therefore independent of the muzzle velocity and depends only on the value of $z = X / C$. That is, for the same range and ballistic coefficient, the ratios of the tangents of the angles of departure and angles of fall are equal for all trajectories described by varying the muzzle velocity, within the limits of direct fire. The functions A'' and C''' are also independent of the muzzle velocity. Whence it follows that the maximum ordinates of all trajectories described as above are proportional to the tangents of the angles of departure (or angles of fall); and the squares of the times of flight are inversely proportional to the tangents of these angles, and therefore inversely proportional to the maximum ordinates.

If we have a table of the functions u, A, A', B, T', C', C'', for a particlar muzzle velocity and with z as argument, their values for any other muzzle velocity within the range of the quadratic law of resistance can be readily determined by the relations given in equations (22) to (26). Thus we have for a muzzle velocity V

$$u_v = \frac{Vu}{800}$$

$$A_v = A\left(\frac{800}{V}\right)^2$$

$$A'_v = A'\left(\frac{800}{V}\right)^2$$

$$B_v = B\left(\frac{800}{V}\right)^2$$

$$T'_v = \frac{800\ T'}{V}$$

$$C'_v = C'\left(\frac{800}{V}\right)^2$$

$$C''_v = \frac{800\ C''}{V}$$

where the letters without subscripts refer to the accompanying table which was computed for a muzzle velocity of 800 f. s. By using these formulas the labor of double interpolation (that is, interpolation with reference to both z and V) is avoided, which is not only a saving of time but insures greater accuracy in the results.

If we consider the following seven quantities,—which may be regarded as the primary elements of a trajectory,—namely, C, V, X, φ, ω, v, T, it will be found that if any three of them be known the remaining four can be computed by the formulas already given. There may therefore be thirty-five cases involving only primary elements. These are not all of equal importance and some of the cases may be of very little value in gunnery; but for the sake of completeness they are all solved in the problems following and illustrated by numerical examples.

PROBLEM ONE.

Given: C, V, X. Required: φ, ω, v, T.

Solution.—Compute $z = X / C$ and with this take from the table u, A, $\log B'$, T'. Then by the preceding formulas

$$\sin 2\varphi = A\ C\left(\frac{800}{V}\right)^2$$

$$\tan \omega = B' \tan \varphi$$

$$T = \frac{800\ C\ T'}{V \cos \varphi}$$

$$v = \frac{V u \cos \varphi}{800 \cos \omega}$$

Example 1.—$C = 2$, $V = 700$ f. s., $X = 1000$ yards.

We first find $z = 1500$, and then from the table, $u = 745.9$, $A = .07902$, $\log B' = 0.02031$, $T' = 1.943$. Whence by the formulas, $\varphi = 5^\circ\ 57'\ 20''$, $\omega = 6^\circ\ 14'$, $v = 653$ f. s., $T = 4.465$ seconds.

For the same range and projectile A and C are constant in the above expression for $\sin 2\varphi$, and therefore for two values of φ and V, distinguished by subscripts, we have

$$\frac{\sin 2\varphi_1}{\sin 2\varphi_2} = \left(\frac{V_2}{V_1}\right)^2$$

That is, for the same range and ballistic coefficient, the sines of twice the angles of departure are inversely as the squares of the corresponding muzzle velocities.

Example 2.—In Ex. 1 suppose X and C to remain the same as there given while V becomes 750° f. s. What will be the value of φ?

We have

$$\sin 2\varphi = \left(\frac{700}{750}\right)^2 \sin 11^\circ\ 54'\ 40''$$

$$\therefore\quad \varphi = 5^\circ\ 10'\ 45''$$

Example 3.—Let X and C remain the same as before and φ be changed to 10. What will be the muzzle velocity?

Answer.

$$V = 700\left(\frac{\sin 11^\circ\ 54'\ 40''}{\sin 20^\circ}\right)^{\frac{1}{2}} = 543.78 \text{ f. s.}$$

It will be seen from these examples that if we have a range table for curved or indirect fire for a muzzle velocity V, we can, without recourse to any ballistic table, compute another range table having a different muzzle velocity.

PROBLEM TWO.

Given: C, V. φ. Required: X, ω, v, T.

Solution.—Compute

$$A = \frac{\sin 2\varphi}{C}\left(\frac{V}{800}\right)^2$$

and with this take from the table z, u, $\log B'$, T'. We then have

$$X = Cz$$

$$\tan\omega = B'\tan\varphi$$

$$v = \frac{Vu\cos\varphi}{800\cos\omega}$$

$$T = \frac{800\,C\,T'}{V\cos\varphi}$$

Example 1.—$C = \frac{1}{10}$, $V = 200$ f. s., $\varphi = 10^\circ$.

We find $A = .21376$, and from the table, $z = 3768.9$, $u = 670.7$, $\log B' = 0.05098$, $T' = 5.152$. Therefore $X = 376.9$ feet, $\omega = 11^\circ\ 13'$, $v = 168.35$ f. s., $T = 2.093$ sec.

Example 2.—The official range table* for the army magazine rifle gives $\varphi = 1° 40' 35''$ for a range of 1000 yards. Suppose we wish to practice with the sight set for this range but with a reduced charge giving a muzzle velocity of 400 f. s. How far off should the target be placed to simulate the 1000-yard range? Take $\log C = 9.46553$ which results from making $c = 1.197$.

We find $A = .050054$ and $z = 966.2$. Therefore $X = 282.23$ feet.

With the sight set for 500 yards, 1500 yards, or 2000 yards, we find in a similar manner, $X = 93.1$ ft., 571.2 ft. and 970.5 ft., respectively.

PROBLEM THREE.

Given: C, X, φ. Required: V, ω, v, T.

Solution.—Compute $z = X / C$ and with this take from the table u, A, $\log B'$, T'. Then

$$V = 800 \left(\frac{A C}{\sin 2 \varphi}\right)^{\frac{1}{2}}$$

$$\tan \omega = B' \tan \varphi$$

$$v = \frac{V u \cos \varphi}{800 \cos \omega}$$

$$T = \frac{800\, C T'}{V \cos \varphi}$$

Example 1.—$C = 2$, $X = 1600$ yards, $\varphi = 10°$.

We find $z = 2400$, and from the table, $u = 715.1$, $A = .13016$, $\log B' = 0.03248$, $T' = 3.175$. Therefore $V = 697.95$, $\omega = 10° 46' 30''$, $v = 625.4$ f. s., $T = 7.391$ sec.

Example 2.—Suppose that in gallery practice with the army magazine rifle, $X = 50$ ft., and we wish to set the sight for a range of 1000 yds. What should be the muzzle velocity in order to hit the center of the target?

We have $\varphi = 1° 40' 35''$, $X = 50$ ft., $\log C = 9.46553$. Therefore $z = 171.18$ and $A = .00865$. Whence $V = 166.3$ f. s.

If we make $X = 100$ yds., we shall find that when the sight is set either for 500 yds., 1000 yds., 1500 yds., or 2000 yds., the following corresponding muzzle velocities will be required, namely, 726.0 f.s., 412.8 f.s., 285.6 f.s. and 214.3 f.s. Thus with suitable cartridges the 100-yard range (or any other convenient distance) can be used for the preliminary practice in sighting for all the ranges. It is believed that the process indicated in this example would give to the rather tiresome sighting drill, much of the excitement and interest attaching to actual target practice.

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* G. O. 36, A. G. O., June 11, 1897, page 89.

Example 3.—What initial velocity must be given to a golf ball to send it 150 yards before striking the ground (supposed to be horizontal), with an angle of rise (or departure) of 10°?

The weight of a *new* Silvertown golf ball is 41.877 grammes (a little less than $1\frac{1}{2}$ ounces), and its diameter is $1\frac{11}{16}$ inches.* The theoretical value of c is 1.391, which in the absence of experiment, we will adopt. This gives $\log C = 8.36749 - 10$.

We now have $z = X / C = 19,307$,—which is below the limit of our table. To work the example it will be necessaay to compute A by Eq. (22), in which

$$\log \frac{g}{A_1 V^2} = 0.0312446,$$

and

$$n = [5.9709214 - 10] z.$$

We find $A = 1.95110$ and then $V = 291.7$ f. s.

The following calculations have been made in a similar manner:

$X = 150$ yards.			$X = 200$ yards.		
φ	V	V In vacuo	φ	V	V In vacuo
10°	291.7 f.s.	205.7 f.s.	10°	387.1 f.s.	237.5 f.s.
20	215.8	150.0	20	288.2	173.3
30	187.8	129.3	30	252.0	149.3
40	181.6	121.2	40	247.2	140.0
45	183.6	120.3	45	252.1	138.9

For these comparatively low velocities the parabolic theory (motion *in vacuo*) would give approximately correct results for artillery projectiles, but not for a golf ball, as a comparison of these values of V shows.

They also illustrate the fact, already well known, that the angle of departure giving the maximum range in air is less than 45°.

It would seem from these, and from other similar calculations, that for a long drive, where the ball strikes on ground that precludes rolling, the angle of departure should be about 42°.

PROBLEM FOUR.

Given : C, φ, ω. Required : V, X, T, v.

Solution.—Compute $\log B' = \log \tan \omega - \log \tan \varphi$, and with this take from the table z, u, A, T'. We then have

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* I am indebted to Lieutenant Richmond P. Davis for these data.

$$X = Cz$$

and V, T, v as in Prob. Three.

Example.—$C = \frac{1}{2}$, $\varphi = 8°$, $\omega = 10°$.

We find $\log B' = 0.09852$, $z = 7302.2$, $u = 568.54$, $A = 0.4669$[illegible], $T' = 10.880$; and by the formulas, $V = 736.24$ f. s., $X = 121$[illegible]7 yds., $T = 5.967$ sec. and $v = 526.13$ f. s.

PROBLEM FIVE.

Given: V, X, φ. Required: C, T, ω, v.

Solution.—Compute

$$\log C' = \log \sin 2\varphi + 2 \log \left(\frac{V}{800}\right) - \log X,$$

and with this take from the table z, u, $\log B'$, T'. We then have

$$C = X / z$$

and T, ω, v as in Prob. One.

Example.—$V = 800$ f. s., $X = 2000$ yds., $\varphi = 10°$.

We find $\log C' = 5.7559 - 10$, $z = 3921.4$, $u = 665.94$, $\log B' = 0.05304$, $T' = 5.380$; and by the formulas $\log C = 0.18471$, $T = 8.359$ sec., $\omega = 11° 16'$, $v = 668.7$ f. s.

PROBLEM SIX.

Given: V, φ, T. Required: C, X, ω, v.

Solution.—Compute $\log C'' = \log \frac{V}{800} + \log \sin \varphi - \log T$, and with this take from the table z, u, A, $\log B'$, We then have

$$C = \frac{\sin 2\varphi}{A} \left(\frac{V}{800}\right)^2$$

and X, ω, v as in Prob. Two.

Example.—$V = 300$ f. s., $\varphi = 10°$, $T = 3$ seconds.

By computation $\log C'' = 8.33658$, and from the table $z = 8409$, $u = 539.9$, $A = 0.55904$, $\log B' = 0.11334$. With these values the formulas give $\log C = 8.93467 - 10$, $X = 723.5$ ft., $\omega = 12° 54'$, $v = 204.5$ f. s.

PROBLEM SEVEN.

Given: V, φ, ω. Required: C, X, T, v.

Solution.—Compute $\log B' = \log \tan \omega - \log \tan \varphi$, and with this take from the table z, u, A, T'. We then have

$$C = \frac{\sin 2\varphi}{A} \left(\frac{V}{800}\right)^2$$

and X, T, v as in Prob. Two.

Example.—$V = 700$ f. s., $\varphi = 10^\circ$, $\omega = 12^\circ$.

By computation $\log B' = 0.08115$, and from the table $z = 6008.2$, $u = 604.1$, $A = 0.36739$, $T' = 8.672$. With these tabular values the formulas give $\log C = 9.85294$, $X = 4282.3$ ft., $T = 7.173$ seconds, $v = 532.2$ f. s.

PROBLEM EIGHT.

Given: X, φ, T. Required: C, V, ω, v.

Solution.—Compute $\log C''' = \log (2\,X) + \log \tan \varphi - 2 \log T$, and with this take from the table z, u, B, $\log B'$. We then have

$$C = X / z$$

and V, ω, v as in Prob. Three.

Example 1.—The six shots fired from the 8-inch pneumatic torpedo gun at Fort Lafayette, September 20, 1887, at the Schooner *Silliman*, give the following data: Diameter of projectile 7.75 inches, weight of projectile (including charge of 55 lbs. of explosive-gelatine and dynamite), 137⅙ lbs.; mean range 5583.5 ft.; angle of departure 14° 53′ 20″; mean time of flight 10.63 seconds.*

Here $2\,X = 11167$ feet, $\varphi = 14^\circ\ 53'\ 20''$, $T = 10.63$ seconds. Therefore $\log C''' = 1.41955$, and from the table, $z = 13925$, $u = 417$, $A = 1.13497$, $\log B' = 0.18621$. With these numbers the formulas give $\log C = 9.60311$, $V = 765.8$ f. s., $\omega = 22^\circ\ 12'$, $v = 416.7$ f. s.

A standard projectile of the same diameter and weight would give $\log C = 0.35865$. Whence it follows that this projectile with its spiral wings for imparting rotation and its very unsteady flight, suffered a resistance more than 5½ times that of a service projectile.

These projectiles have been very much improved since the date of the above firing. From the report of the firing of a pneumatic torpedo gun at Shoeburyness, England, in the summer of 1890, made by B. C. Batcheller, S. B.,† with 8 and 10-inch sub-caliber and 15-inch full caliber dummy projectiles, is taken the following data:

8-inch.	10-inch.
$w = 298$ lbs.	$w = 493$ lbs.
$d = 8.27$ in.	$d = 10.25$ in.
$\varphi = 15^\circ\ 8'$	$\varphi = 15^\circ\ 10'$
$X = 2931$ yds.	$X = 2298$ yds.
$T = 12.835$ sec.	$T = 11.2$ sec.

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* This example will also be found in Ingalls' *Handbook*, page 117; in *Balistique Extérieure* by Vallier, page 93; and in *Problemas de Balistica* by La Llave, page 67.

† See *Journal U. S. Artillery*, whole No. 19.

With these data Prob. Eight readily gives for the 8-inch gun $V = 822$ f. s., $c = 2.834$; and for the 10-inch gun $V = 718.6$ f.s., $c = 3.403$.

It will be seen that the "laborious tentative process" by which this problem was originally solved is reduced by this method to a simple, direct and easy process of as many minutes as the former required hours.

PROBLEM NINE.

Given: X, φ, ω. Required: C, V, T, v.

Solution.—Compute $\log B' = \log \tan \omega - \log \tan \varphi$, with which take from the table z, u, A, T'. We then have

$$C = X / z$$

and V, T, v as in Prob. Three.

Example.—$X = 1000$ yds., $\varphi = 15°$, $\omega = 16°$.

We find $\log B' = 0.02944$, $z = 2175.6$, $u = 722.6$, $A = 0.11714$, $T' = 2.863$. Whence $\log C = 0.13954$, $V = 454.7$ f. s., $T = 7''.191$ and $v = 412.7$ f. s.

PROBLEM TEN.

Given: φ, T, ω. Required: C, V, X, v.

Solution.—Compute $\log B'$ as in Prob. Nine, with which take from the table z, u, A, T'. We then have

$$C = \frac{A}{2 \tan \varphi}\left(\frac{T}{T'}\right)^2$$

and V, X, v as in Probs. Two and Three.

Example.—$\varphi = 15°$, $T = 13$ sec., $\omega = 16°$.

We find $\log B'$, z, u, A and T' as in Prob. Nine. Whence $\log C = 0.65387$, $V = 821.8$ f. s., $X = 9805$ ft., and $v = 744.7$ f. s.

PROBLEM ELEVEN.

Given: φ, ω, v. Required: C, V, X, T.

Solution.—Compute $\log B'$ as in Prob. Nine, with which take from the table z, u, A, T'. We then have

$$V = \frac{800\, v \cos \omega}{u \cos \varphi}$$

and C, X, T as in Probs. Two and Six.

Example.—$\varphi = 5°$, $\omega = 7° 30'$, $v = 50$ f. s.

We find $\log B' = 0.17748$, $z = 13257.25$, $u = 430.3$, $A = 1.05330$, $T' = 22.959$. Whence $V = 93.4$ f. s., $\log C = 7.35166 - 10$, $X = 37.51$ ft., $T = 0.4436$ sec.

PROBLEM TWELVE.

Given: C, X, ω. Required: V, φ, v, T.

Solution.—Compute $z = X / C$ with which take from the table u, A log B', T'. Then compute

$$\tan\varphi = \frac{\tan\omega}{B'}$$

and V, v, T as in Probs. One and Two.

Example 1.—$C = 2$, $X = 1000$ yds., $\omega = 15°$.

We find $z = 1500$, $u = 745.9$, $A = .07902$, $\log B' = 0.02031$, and $T' = 1.943$. Therefore by the formulas, taken in order of computation, $\varphi = 14° \; 20' \; 40''$, $V = 459.0$ f. s., $v = 429.3$ f. s., $T = 6.991$ sec.

Example 2.—It is desired to open a searching fire upon the enemy (protected by cover from direct fire), with shrapnel from a battery of 3.2-inch field guns, at 2000 yards. The angle of descent should be 20° to be effective. What must be the muzzle velocity and angle of elevation—also striking velocity and time of flight?

Here $X = 6000$, $\omega = 20°$, and $\log C = 0.00816$. We find $z = 5888.3$, $A = .35859$, $\log B' = 0.07954$, $T' = 8.474$ and $u = 607.4$. Therefore by the formulas, $\varphi = 16° \; 51' \; 30''$, $V = 649.01$ f. s., $v = 501.9$ f. s., $T = 11.121$ sec.

If it were considered desirable to increase the angle of fall without changing the position of the battery, it could be done only by increasing the angle of elevation and decreasing the muzzle velocity. Suppose we increase the angle of departure to 20°, what should the muzzle velocity be?

Answer. $$V = 649.01\left(\frac{\sin 33° \; 43'}{\sin 40°}\right)^{\frac{1}{2}} = 603.2 \text{ f. s.}$$

PROBLEM THIRTEEN.

Given: C, φ, T. Required: V, X, ω, v.

Solution.—We have the relation

$$\frac{C \tan\varphi}{T^2} = \frac{A}{T'^2} = \frac{C''}{T'}$$

by means of which C'' / T' (or rather its logarithm) is to be computed, and then z found from the table by inspection and trial. Then take from the table u, A, log B' by means of which the required elements can be computed as in Probs. Two and Three.

In preparing the accompanying table it would have been easy to compute an additional column for C'' / T', by means of which the value of z in any particular case could be taken out directly. But the importance of the problem does not warrant such an extension of the table. The value of z can be found with very little labor by inspection and trial.* The same remark applies to fourteen of the thirty-five problems involving only primary elements.

Example.—$C = 3$, $\varphi = 5°$, $T = 3$ sec.

We find $\log C'' - \log T' = 8.46483 - 10$, which is satisfied when $z = 546.18$. Therefore $u = 779.9$, $A = 0.02792$, $\log B' = 0.00740$. Whence $V = 555.6$ f. s., $X = 1638.54$ ft., $\omega = 5° 5'$, $v = 541.7$.

PROBLEM FOURTEEN

Given: C, T, ω. Required: V, X, φ, v.

Solution.—Compute

$$\frac{B}{T'^2} = \frac{2\,C \tan \omega}{T^2}$$

with which find z from the table by inspection and trial. Th take out u, A, $\log B'$ and compute

$$\tan \varphi = \frac{\tan \omega}{B'}$$

and the other required elements as in Probs. Two and Three.

Example.—$C = 2$, $T = 10$ sec., $\omega = 20°$.

We find $\log \dfrac{B}{T'^2} = 8.16313$, and by trial, this is satisfied when $z = 2289$. Therefore $u = 718.8$, $A = 0.12369$, $\log B' = 0.03098$. Whence $X = 4578$ ft., $\varphi = 18° 43'$, $V = 510.4$ f. s., $v = 462.2$ f.s.

PROBLEM FIFTEEN.

Given: C, ω, v. Required: V, X, φ, T.

Solution.—Compute

$$B\,u^2 = \frac{v^2 \sin 2\omega}{C}$$

with which find z from the table by inspection and trial, and then take out u, $\log B'$, T'. We then compute the required elements as in Probs. Two, Three and Fourteen.

Example 1.—$C = 1$, $\omega = 15°$, $v = 200$ f.s. We have

$$B\,u^2 = 20{,}000$$

from which we find $z = 635.2$, and then $u = 776.6$, $\log B' = 0.00861$, $T' = 0.806$. Whence $V = 206.0$ f. s., $X = 635.2$ ft., $\varphi = 14° 43'$, $T = 3.236$ sec.

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* See *Handbook*, pages 62-64 for an illustration of the method by "trial and error".

Example 2.—"An escarp had to be breached at the siege of Strasburg by a gun, equivalent to an 8-inch howitzer of 70 cwt., on the same level. From information received from a spy, the ditch was known to be about 50 feet wide; in consequence of which the necessary angle of descent was calculated to be 14°. The howitzer was using common shell and delay-action fuze, and the Engineers required that the striking velocity was not to fall short of 600 f. s.

Find the least requisite distance of the howitzer from the escarp, the necessary muzzle velocity and angle of departure."*

Here $w = 180$, $d = 8$, $c = \frac{10}{9}$, $\log C = 0.40333$, $v = 600$ f.s., $\omega = 14°$. Our trial equation is

$$\log B u^2 = 4.82458$$

from which we find $z = 2221.7$, and then $u = 721.1$, $\log B' = 0.03007$, $T' = 2.927$. Therefore $V = 663.1$ f. s., $X = 1875$ yds., $\varphi = 13° 6'$, $T = 9.177$ sec.

The muzzle velocity in this problem may be computed approximately by means of the inclination and time functions, and the velocity at the summit of the trajectory (v_0). We have approximately, and assuming that $\cos \varphi = \cos \omega$,

$$I(v_0) = I(v) - \frac{\sin 2\omega}{C}$$

by means of which v_0 can be computed. Then upon the hypothesis that the time from the origin to the summit is equal to the time from the summit to the point of fall, we have†

$$T(V) = 2\,T(v_0) - T(v)$$

which gives V. We then have

$$u = \frac{800\,v}{V}$$

by means of which z, $\log B'$ and T' can be taken from the table as before.

PROBLEM SIXTEEN.

Given: X, T, ω. Required: C, V, φ, v.

Solution.—Compute

$$\frac{B z}{T'^2} = \frac{2 X \tan \omega}{T^2}$$

and with this find z from the table by inspection and trial, and take out u, A, $\log B'$. The required elements can then be computed as in Probs. Three, Five and Fourteen.

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* *Text Book of Gunnery.* London. 1897. Page 269.

† *Handbook.* Pages 61-62.

Example.—$X = 1000$ yds., $T = 7$ sec., $\omega = 16°$.

We find $z = 5531.3$, $u = 617.7$, $A = 0.33278$, $\log B' = 0.07474$.

Whence $\log C = 9.73429$, $V = 503.2$ f.s., $\varphi = 13° \, 34' \, 20''$, $v = 391.0$ f. s.

PROBLEM SEVENTEEN.

Given: X, ω, v. Required: C, V, φ, T.

Solution.—Compute

$$\frac{B\,u^2}{z} = \frac{v^2 \sin 2\,\omega}{X}$$

and with this find z from the table by inspection and trial, and take out u, A, $\log B'$, T'. The required elements are then computed as in Probs. Three, Five and Fourteen.

Example.—$X = 2000$ yds., $\omega = 15°$, $v = 600$ f. s.

We find $z = 2270$, $u = 719.4$, $A = .12259$, $\log B' = 0.03072$, $T' = 2.994$. Therefore $\log C = 0.42212$, $\varphi = 14° \, 1'$, $V = 664.2$ f. s., $T = 9.823$ sec.

PROBLEM EIGHTEEN.

Given: T, ω, v. Required: C, V, X, φ.

Solution.—Compute

$$\frac{B\,u}{T'} = \frac{2\,v \sin \omega}{T}$$

and with this find z from the table by inspection and trial. Then take out u, A, $\log B'$ and compute the required elements as in Probs. Two, Six, Eleven and Fourteen.

Example.—$T = 2.2$ sec., $\omega = 20°$, $v = 100$ f. s.

We find from the table $z = 4788$, $u = 639.6$, $A = .28093$, $\log B' = 0.06474$. Therefore $\log C = 8.68293$, $V = 123.18$ f. s., $X = 230.7$ ft., $\varphi = 17° \, 24' \, 35''$.

PROBLEM NINETEEN.

Given: C, V, ω. Required: X, φ, T, v.

Solution.—For a first approximation assume

$$\cos \varphi = \cos \omega,$$

and compute

$$B = \frac{\sin 2\,\omega}{C}\left(\frac{V}{800}\right)^2$$

with which take from the table z, u, A, T', and then compute X, φ, T, v as in Probs. One and Two. Repeat if necessary making

$$B = \frac{2 \cos^2 \varphi \tan \omega}{C} \left(\frac{V}{800}\right)^2$$

which is its true value.

Example.—$C = 3$, $V = 650$, $\omega = 5°$.

We find by computation $B = .0382$ and then from the table $z = 727.3$, $u = 773.3$, $A = .03739$, $T' = 0.925$. Whence $X = 2181.9$ ft., $\varphi = 4° \, 53'$, $T = 3.428$ sec., $v = 628.3$ f. s. These results are practically correct; but when φ and ω differ considerably from each other it will be necessary to repeat where great accuracy is desired.

PROBLEM TWENTY.

Given: C, V, v. Required: X, φ, T, ω.

Solution.—Assuming $\cos \varphi = \cos \omega$, compute

$$u = \frac{800\, v}{V}$$

with which take from the table z, A, $\log B'$, T', and then compute the required elements as in Probs. One and Two. If considered necessary u can be re-computed by the accurate formula

$$u = \frac{800\, v \cos \omega}{V \cos \varphi}$$

Example.—$C = 1$, $V = 800$, $v = 732$.

We find $u = 732$ and from the table $z = 1900$, $A = .10139$, $\log B' = 0.02572$, $T' = 2.484$. Therefore $X = 1900$ ft., $\varphi = 2° \, 54' \, 30''$, $\omega = 3° \, 5'$, $T = 2.487$ sec.—which need no correction.

PROBLEM TWENTY-ONE.

Given: C, X, v. Required: V, φ, T, ω.

Solution.—Compute $z = X / C$, with which take from the table u, A, $\log B'$, T'. Then assuming for a first approximation, $\cos \varphi = \cos \omega$, compute

$$V = \frac{800\, v}{u}$$

and then φ, T, ω as in Probs. One and Two. Repeat if necessary, making

$$V = \frac{800\, v \cos \omega}{u \cos \varphi}$$

which is its true value.

Example.—$C = 1$, $X = 3000$, $v = 600$.

We have $z = 3000$, and from the table $u = 695.3$, $A = 0.16590$, $\log B' = 0.04059$, $T' = 4.026$. Whence $V = 690.4$, $\varphi = 6° \, 26'$, $T = 4.662$ sec., $\omega = 7° \, 3' \, 30''$.

PROBLEM TWENTY-TWO.

Given: V, X, v. Required: C, φ, T, ω.

Solution.—Assuming $\cos\varphi = \cos\omega$, compute

$$u = \frac{800\,v}{V}$$

with which take from the table z, A, $\log B'$, T'. Then compute

$$C = \frac{X}{z}$$

and the other elements as in Probs. One and Two. Repeat if necessary making

$$u = \frac{800\,v\cos\omega}{V\cos\varphi}.$$

Example.—$V = 800$, $X = 4000$ ft., $v = 692$.

We have $u = 692$, whence $z = 3100$, $A = .17199$, $\log B' = 0.04194$, $T' = 4.170$. Therefore $\log C = 0.11070$, $\varphi = 6^\circ\ 24'\ 40''$, $T = 5.415$ sec., $\omega = 7^\circ\ 3'\ 20''$.

PROBLEM TWENTY-THREE.

Given: V, φ, v. Required: C, X, T, ω.

Solution.—Compute u as in Prob. Twenty-Two, and take z, A, $\log B'$ and T' from the table. Then compute the required elements by the formulas given in Probs. Two and Six. Repeat if necessary, as in Prob. Twenty-Two.

Example.—$V = 200$, $\varphi = 2^\circ$, $v = 116.25$.

We have $u = 465$, whence $z = 11600$, $A = .86592$, $\log B' = 0.15570$, $T' = 19.152$. Therefore $\log C = 7.70198 - 10$, $X = 58.4$ ft., $T = 0.388$ sec., $\omega = 2^\circ\ 51'\ 40''$.

PROBLEM TWENTY-FOUR.

Given: V, T, v. Required: C, X, φ, ω.

Solution.—Compute u as in Prob. Twenty-Two, and take z, A, $\log B'$, T' from the table. We then have

$$\sin\varphi = \frac{A}{2}\frac{T}{T'}\left(\frac{800}{V}\right)^2$$

and C, X, ω as in Probs. Two and Six. Repeat with $\cos\varphi$ and $\cos\omega$ if necessary.

Example.—$V = 800$, $T = 2$, $v = 732$.

We find $z = 1900$, $u = 732$, $A = .10139$, $\log B' = 0.02572$. Whence $\log C = 9.90554 - 10$, $X = 1528.6$ ft., $\varphi = 2^\circ\ 20'\ 22''$, $\omega = 2^\circ\ 28'\ 55''$.

[illegible] TW[illegible]Y-FIVE.

[illegible] v. [illegible]: C, X, φ, T.

S[illegible]—[illegible] as [illegible] Prob. T[illegible]nty-Two and take z, A, log [illegible] t[illegible] T[illegible] quantities are then computed in [illegible], F[illegible]. Repeat if necessary, as [illegible] T[illegible]nty-T[illegible]

[illegible]ple.—[illegible] $= 800$, $\omega = 20°$, $v = 692$.

[illegible] f[illegible]ximation, $z = 3100$, $u = 692.0$, log B' [illegible] 0.04194. T[illegible] $\varphi = 18° \; 17' \; 10''$. Now re-computing u, [illegible]troducing cos φ [illegible] ω we get $u = 684.86$, $z = 3323$, log B' [illegible] 0.04496. [illegible] $\varphi = 18° \; 10' \; 10''$. Repeating the operation [illegible] finally $u = 684.4$, $z = 3337.5$, $A = .18262$, l[illegible]: 0.04516, $T' = 4.515$. Therefore log $C = 0.50160$, $X =$ 1[illegible]3 ft., $\varphi = 18° \; 9' \; 40''$, $T = 15.082$ sec.

PROBLEM TWENTY-SIX.

Given: C, φ, v. Required: V, X, T, ω.

Solution.—Assuming cos φ = cos ω, compute

$$Au^2 = \frac{v^2 \sin 2\varphi}{C}$$

and with this find z from the table by inspection and trial. Then take out u, A, log B', T' and compute the required elements as in Probs. Two and Three. If necessary repeat making

$$Au^2 = \frac{2\,v \tan\varphi \cos^2\omega}{C}$$

hich is the true value.

Example.—$C = 5$, $\varphi = 2°$, $v = 500$.

We find $z = 109.14$, $u = 796$, $A = .00550$, log $B' = 0.00147$, $T' = 0.137$. Therefore $V = 502.3$, $X = 545.7$ ft., $\omega = 2° \; 00' \; 24''$, $T = 0.685$ sec.

PROBLEM TWENTY-SEVEN.

Given: V, T, ω. Required: C, X, φ, v.

Solution.—Assuming cos φ = cos ω, compute

$$\frac{B}{T'} = \frac{2\,V \sin\omega}{800\,T}$$

with which find z from the table by inspection and trial, and take out u, A, log B'. The required elements are then computed as in Probs. One, Four, Six and Twelve. Repeat if necessary making

$$\frac{B}{T'} = \frac{2\,V \cos\varphi \tan\omega}{800\,T}$$

Example.—$V = 800$ f. s., $T = 4$ sec., $\omega = 5°$.

We find $\log \frac{B}{T'} = 8.63927$ which is satisfied when $z = 2046$. Therefore $u = 727.0$, $A = .10970$, $\log B' = 0.02769$, and $\log C = 0.17208$, $X = 3041$ ft., $\varphi = 4° \; 41' \; 30''$, $v = 727$ f. s. These require no correction.

PROBLEM TWENTY-EIGHT.

Given: X, φ, v. Required: C, V, T, ω.

Solution.—Assuming $\cos \varphi = \cos \omega$, compute

$$\frac{A u^2}{z} = \frac{v^2 \sin 2\varphi}{X}$$

with which find z from the table by inspection and trial, and take out u, A, $\log B'$, T'. The required elements are then computed as in Probs. Three and Five. Repeat if necessary by making

$$\frac{A u^2}{z} = \frac{2 v^2 \tan \varphi \cos^2 \omega}{X}$$

Example.—$X = 1600$ ft., $\varphi = 5°$, $v = 540$ f. s.

We find $\log \frac{A u^2}{z} = 1.50034$, which is satisfied when $z = 253.4$. Therefore $u = 790.6$, $A = .01283$, $\log B' = 0.00343$, $T' = 0.319$. Whence $\log C = 0.80031$, $V = 546.4$ f. s., $T = 3.727$ sec., $\omega = 5° \; 2' \; 20''$.

PROBLEM TWENTY-NINE.

Given: φ, T, v. Required: C, V, X, ω.

Solution.—Assuming $\cos \varphi = \cos \omega$, compute

$$\frac{Au}{T'} = \frac{2 v \sin \varphi}{T}$$

with which find z from the table by inspection and trial, and take out u, A, $\log B$, T'. Compute the required elements as in Probs Three, Four, Ten, Twelve. Repeat if necessary by making

$$\frac{Au}{T'} = \frac{2 v \tan \varphi \cos \omega}{T}$$

Example.—$\varphi = 5°$, $T = 4$ sec., $v = 550$ f. s.

We find $\log \frac{Au}{T'} = 1.37963$, which is satisfied when $z = 7794.3$. Therefore $u = 555.6$, $A = .50705$, $\log B' = 0.10511$, $T' = 11.755$. Whence $\log C = 9.52575$, $V = 791.9$ f. s., $X = 2615$ ft., $\omega = 6° \; 21' \; 30''$. These are close approximations.

PROBLEM THIRTY.

Given: V, X, ω. Required: C, φ, T, v.

Solution.—Assuming $\cos\varphi = \cos\omega$, compute

$$\frac{B}{z} = \frac{\sin 2\omega}{X}\left(\frac{V}{800}\right)^2$$

with which find z from the table by inspection and trial, and take out $u, A, \log B', T'$. We then compute the required elements as in Probs. One and Five. Repeat if necessary making

$$\frac{B}{z} = \frac{2\cos^2\varphi\tan\omega}{X}\left(\frac{V}{800}\right)^2$$

Example.—$V = 550$ f. s., $X = 1600$ f. s., $\omega = 5°$.

We find $\log\frac{B}{z} = 5.71009 - 10$, which is satisfied when $z = 296.5$. Therefore $u = 789.0$, $A = .01503$, $\log B' = 0.00401$, $T' = 0.374$. Whence $\log C = 0.73210$, $\varphi = 4° 57' 15''$, $T = 2.947$ sec., $v = 542.4$ f. s.

PROBLEM THIRTY-ONE.

Given: C, V, T. Required: X, φ, ω, v.

Solution.—For a first approximation assume

$$\cos\varphi = 1,$$

and compute

$$T' = \frac{T}{800}\frac{V}{C}$$

with which take A from the table, and compute

$$\sin 2\varphi = AC\left(\frac{800}{V}\right)^2$$

With this value of φ compute

$$T' = \frac{T}{800}\frac{V\cos\varphi}{C}$$

which is the complete expression for T', and take from the table $z, u, A, \log B'$. The required elements can then be computed as Probs. One and Two.

Example.—$C = 3$, $V = 800$, $T = 10$.

We first find $T' = 3\frac{1}{3}$ and $\varphi = 12° 7'$. Next $T' = 3.259$, $z = 2460$, $u = 713.0$, $A = 0.13368$, $\log B' = 0.03329$. Whence $X = 7380$ ft., $\varphi = 11° 49'$, $\omega = 12° 44'$, $v = 715.5$ f. s. It might be necessary for extreme accuracy to again repeat the calculation using the last value of φ.

PROBLEM THIRTY-TWO.

Given: C, X, T. Required: V, φ, ω, v.

Solution.—Compute $z = X / C$ and with this take from the table u, A, log B', T'. We then have

$$V = \frac{800\ C\ T'\cos\varphi}{T}$$

and the required elements as in Prob. One. It will be necessary to assume

$$\cos\varphi = 1,$$

which is accurate enough when φ is less than 5°. For greater values of φ we must repeat the operation as many times as is necessary.

Example.—$C = 3$, $X = 2000$ yds., $T = 10$ sec.

We find $z = 2000$, $u = 728.6$, $A = 0.10707$, $\log B' = 0.02707$, $T' = 2.621$. Omitting $\cos\varphi$ we find $V = 629.04$ and $\varphi = 15° 39'$. Introducing $\cos\varphi$ and repeating the operation four times we finally obtain $V = 600.3$ f. s. and $\varphi = 17° 23'$ which are their true values. The other elements are $\omega = 18° 26'$, $v = 550.0$ f. s.

PROBLEM THIRTY-THREE.

Given: V, X, T. Required: C, φ, ω, v.

Solution.—Compute

$$\frac{T'}{z} = \frac{T\ V\cos\varphi}{800\ X}$$

assuming for a first approximation $\cos\varphi = 1$. Find z from the table by inspection and trial and take out u, A, log B'. The required elements can then be computed as in Probs. One and Fiv Repeat the operation with $\cos\varphi$ as many times as may be necessary.

Example.—$V = 550$ f. s., $X = 1600$ ft., $T = 3$ sec.
Answer. $\log C = 0.15104$, $\varphi = 5° 4' 35''$, $\omega = 5° 15' 30''$ $v = 5$
f. s.

PROBLEM THIRTY-FOUR.

Given: C, T, v. Required: V, X, φ, ω.

Solution.—Compute

$$T'u = \frac{T\ v\cos\omega}{C}$$

assuming for a first approximation

$$\cos\varphi = \cos\omega = 1.$$

Find z from the table by inspection and trial and take out u, A, log B'. We then have approximately

$$V = \frac{800\, v}{u}$$

$$X = Cz$$

$$\sin 2\varphi = A\,C\left(\frac{800}{V}\right)^2$$

$$\tan \omega = B' \tan \varphi.$$

Repeat as often as may be necessary, supplying the factors cos φ and cos ω in the expression for V, and cos ω in the expression for $T'u$.

***Example.*—log $C = 9.52575 - 10$, $T = 4$ sec., $v = 550$ f.s.**

***Answer.*—$V = 792$ f.s., $X = 2615$ ft., $\varphi = 5°$, $\omega = 6° 21' 30''$.**

PROBLEM THIRTY-FIVE.

Given: X, T, v. Required: C, V, φ, ω.

***Solution.*—Compute**

$$\frac{T'u}{z} = \frac{Tv\cos\omega}{X}$$

and proceed as in Prob. 34.

***Example.*—$X = 1200$ yds., $T = 6$ sec., $v = 525$ f.s.**

We have, by two approximations, log $C = 9.73863$, $V = 710$ f.s., $\varphi = 8° 16'$, $\omega = 10° 6'$.

PROBLEM THIRTY-SIX.

Given: Any three of the seven elements of a trajectory to compute the coordinates of its summit (x_0, y_0), and the summit velocity (v_0).

Solution.—If C, V, A and φ are not already known, compute them by means of the given data as previously explained and illustrated. Find the value of A in the A' column and take out the corresponding values of z, u, A'', designating the first two, since they refer to to the summit, by z_0, u_0. We then have*

$$x_0 = Cz_0$$

$$y_0 = A''\,C\tan\varphi$$

$$v_0 = \frac{V u_0 \cos\varphi}{800}.$$

Example.—Compute x_0, y_0, v for the the trajectory of Prob. 12. Here $C = 2$, $V = 459.0$ f.s.. $A = .07902$, $\varphi = 14° 20' 40''$. Making $A' = .07902$ we find $z_0 = 758.5$, $u_0 = 772.2$, $A'' = 383.8$.

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* *Handbook*, Problem XIII.

Therefore $x_0 = 1517.0$ ft., $y'_0 = 196.29$ ft., $v_0 = 429.2$ f. s. As v_0 differs from v by only a tenth of a foot (Prob. 12), it follows that in this trajectory the point of minimum velocity is near the point of fall.

PROBLEM THIRTY-SEVEN.

Given : y_0, C, φ. Required : The remaining elements of the trajectory.

Solution.—Compute

$$A'' = \frac{y'_0}{C \tan \varphi},$$

with which take A' from the table and find its value in the A column. With this latter take out z, u, log B', T', and compute the elements as in Problems 3 and 4.

Example.—$C = 1$, $\varphi = 10°$, $y_0 = 50$ ft.

We find $A'' = 283.56$, $A' = A = .05796$, $z = 1113.7$. Therefore $X = 1113.7$ ft., $V = 329.3$ f.s.

As the muzzle velocity is quite small in this example, it will be interesting to see how the above range compares with that given by the parabolic theory. By this theory we have

$$X = 4 y'_0 \cot \varphi.$$

Giving to y'_0 and φ the values in the above example we find $X = 1134.3$ ft.

PROBLEM THIRTY-EIGHT.

Given : The elements of a trajectory. Required : The value of y for any given value of x.

Solution.—We have*

$$y = \frac{\tan \varphi}{A} (A - a) x.$$

In this equation A is either taken from the table with the argument

$$z = X / C,$$

or it may be computed by the formula

$$A = \frac{\sin 2 \varphi}{C} \left(\frac{V}{800} \right)^2.$$

The quantity a varies with the abscissa x, and is taken from the same column as A with the argument x / C.

Example 1.—$V = 850$ f.s., $\varphi = 15°$, $C = 5$. Compute the maximum ordinate, and the ordinate when

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* *Handbook*, Problem XV.

$$x = X - 100 \text{ ft.}$$

1. We find $A = 0.11289$ and $z = 2101.74$. Therefore $X =$ 10508.7 ft. and $x = 10408.7$. The general expression for y is readily found to be

$$y = [0.37539] \left\{ 0.11289 - a \right\} x.$$

2. For $x = 10408.7$ we find $z = 2081.74$, corresponding to which in the A column we have $a = 0.11175$, and then $y = 28.2$ ft. For the maximum ordinate we find $A'' = 515.8$; whence

$$y_0 = 5 \times 515.8 \tan 15° = 691.04 \text{ ft.}$$

***Example* 2.—Suppose that in Ex. 2 of Prob. 15, there was a ridge between the position selected for the gun and the escarp to be breached, whose crest was 80 ft. above the level of the gun and 100 yards from the escarp. Would the shot clear the crest?**

Here from Prob. 15 and the new data, $X = 1875$ yards, $\varphi =$ $13° 6'$, $z = 2221.7$, $A = 0.11979$, $x = 5325$ ft. and $\log C = 0.40333$, to find y. The new value of z from which to get a from the table is $5325/C = 2103.7$, from which $a = .11300$. We next find $\log (\tan \varphi/A)$ to be 0.29295. The general expression for y for this trajectory is therefore

$$y = [0.29295] \left\{ 0.11979 - a \right\} x$$

and supplying the values of a and x for this particular case, we find

$$y = 70.98 \text{ ft.}$$

The projectile would then strike the side of the ridge 9 ft. below its crest. To carry the projectile over the ridge and not diminish the striking velocity the gun must be placed further from the escarp, supposing the ground to be level. Suppose we assume the gun to be placed 300 yards further from the escarp, would the projectile then clear the ridge? In this case we have $X =$ 2175 yds. = 6525 ft., $\log C = 0.40323$ and $v = 600$ f.s. to find the other elements of the trajectory by Prob. 21 and y as above. In computing V by Prob. 21 we will employ the values of φ and a already given or found, since although they will both be increased by the new data, still the *ratio* of their cosines will be sensibly unaltered. We find $z = 2577.8$, $u = 709.1$, $A = .14061$, $\log B'$ $= 0.03488$. Whence $V = 674.25$ f. s., $\varphi = 15° 2' 5''$, $\omega = 16° 14'$. To compute y we have $x = 6225$ ft., $x/C = 2459.3$ and $a = .13363$ by means of which we find $y = 83.00$ ft. The projectile would then clear the ridge by three feet. We may now determine the distance of the gun from the escarp so that the projectile would just graze the ridge as follows: For a range of 5625 ft. the trajectory passes 9.02 ft. below the crest of the ridge; and for a range of 6525 ft. the trajectory is too high by 3 ft. We therefore have the proportion

$$12 : 900 :: 3 : 225,$$

whence the required range is 6525—225 = 6300 ft. With this value of X we find $z = 2488.9$, and from the table $u = 712.2$, $A = .13537$, $\log B' = 0.03368$. Whence $V = 670$ f.s., $\varphi = 14° 37' 15''$, $\omega = 15° 44' 30''$. The value of y computed for these last data is 80.24 ft. The problem is therefore completely solved.

Example 3.—$V = 200$ m.s., $\varphi = 30°$, $d = 24$ cm., $w = 144$ kg.[*] The complete expression for C when Siacci's factor β is employed is

$$C = f\,\frac{\delta_1}{\delta}\,\frac{w}{c\,d^2\,\beta}$$

In this example f, δ_1/δ and c are each taken as unity and $\beta =$ 1.06.[†] We will give the work entire to show the procedure whe metric units are employed. It will be observed that these unit increase the labor but slightly.

$$\begin{aligned}
\text{Const. log} &= 1.15298\\
\log w &= 2.15836\\
\text{a.c. }\log d^2 &= 7.23958\\
\text{a.c. }\log \beta &= 9.97469\\
\hline
\log C &= 0.52561
\end{aligned}$$

$$\begin{aligned}
\log 200 &= 2.30103\\
\text{Const. log} &= 0.51599\\
\text{a.c. }\log 800 &= 7.09691\\
\hline
\log V/800 &= 9.91393\\
&2\\
\hline
2\log V/800 &= 9.82786\\
\log\sin 2\varphi &= 9.93753\\
\text{a.c. }\log C &= 9.47439\\
\hline
\log A &= 9.23978\\
A &= .17369
\end{aligned}$$

$$z = 3100 + \frac{17000}{613} = 3127.7$$

$$u = 695.3 - .277 \times 3.3 = 694.4$$

$$\log B' = 0.04194 + .277 \times 135 = 0.04231.$$

$$A'' = 820 + \frac{1.9 \times 52}{117} = 828.4$$

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[*] Vallier's *Balistique Extérieure*. Paris, 1895. Page 101.

[†] See Table VI of *Handbook*. This is Siacci's *first* table of these factors and differs slightly from his *new* table, but principally in the longer ranges.

$$\begin{array}{rl}
\log \tan \varphi = & 9.76144 \\
\log B' = & 0.04231 \\ \hline
\log \tan \omega = & 9.80375 \\
\omega = & 32^\circ\ 28'\ 30'' \\
\\
\log u = & 2.84161 \\
\log \cos \varphi = & 9.93753 \\
\log \sec \omega = & 0.07385 \\
\log V/800 = & 9.91393 \\
\text{Const. log} = & 9.48401 \\ \hline
\log v = & 2.25093 \\
v = & 178.2 \text{ m.s.}
\end{array}$$

$$\begin{array}{rl}
\log z = & 3.49523 \\
\log C = & 0.52561 \\
\text{Const. log} = & 9.48401 \\ \hline
\log X = & 3.50485 \\
X = & 3198 \text{ m.} \\
\\
\log C = & 0.52561 \\
\log A'' = & 2.91824 \\
\log \tan \varphi = & 9.76144 \\
\text{Const. log} = & 9.48401 \\ \hline
\log y_0 = & 2.68930 \\
y_0 = & 489 \text{ m.}
\end{array}$$

Example 4.—The same projectile as Ex. 3, and $X = 4000$ m., $\varphi = 35^\circ$. For this range and elevation $\beta = 1.08$, which gives $\log C = 0.51750$.

Answers.—$V = 217.8$ m.s., $\omega = 38^\circ\ 24'\ 20''$, $T = 24.646$ sec., $v = 189.9$ m.s., $y_0 = 744.6$ m.

These results, as well as those of Ex. 3, agree almost exactly with those obtained in an entirely different manner by Vallier.

The "general ballistic tables for mortar firing" published in the *U. S. Artillery Journal*, Vol. V, page 52, also give the same results practically as the above.

Example 5.—$V = 204.1$ m.s., $d = 21$ cm., $w = 91$ kg., $\varphi = 45^\circ$. Determine the range, For this we have $\beta = 1.17$ and $c = 1\frac{1}{9}$, whence $\log C = 0.35736$.

Answer.—$X = 11811$ ft. The mean of five shots fired at Meppen with the above conditions was 11848 ft. See Krupp's *Expériences di tir*, No. 31, January 19, 1892.

Example 6—$V = 220$ m.s., $X = 3000$ m., $\varphi = 22^\circ\ 6'$. Compute C, ω, v, T, x_0, y_0.* We will give the entire work as a further illustration of how to use metric data with English tables. The additional labor involved is not worth mentioning.

The elements of the trajectory are computed by Prob. 5.

$$\begin{array}{rl}
\log \sin 2\varphi = & 9.84334 \\
2 \log V/800 = & 8.87866 \\
\text{a.c. } \log X = & 6.52287 \\
\text{Const. log} = & 0.51599 \\ \hline
\log C' = & 5.76086
\end{array}$$

$$\begin{array}{rl}
\log V = & 2.34242 \\
\log 800 = & 2.90309 \\ \hline
 & 9.43933 \\
 & 2 \\ \hline
 & 8.87866
\end{array}$$

$\therefore\quad z = 4200 + \frac{960}{14} = 4268.6$, and by interpolation with z as argument, $u = 655.2$, $A = .24614$, $\log B' = 0.05773$, $T' = 5.905$. With $A' = A$ as argument we find $A'' = 1140$ and $z_0 = 2204.4$.

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* Siacci, *Balistique*, page 87.

$$\begin{aligned} \log X &= 3.47712 \\ \text{a.c.} \log z &= 6.36971 \\ \text{Const.} \log &= 0.51599 \\ \hline \log C &= 0.36282 \end{aligned}$$

$$\begin{aligned} \log 800 &= 2.90309 \\ \log C &= 0.36282 \\ \log T' &= 0.77122 \\ \text{a. c.} \log V &= 7.65758 \\ \log \sec \varphi &= 0.03314 \\ \text{Const.} \log &= 9.48401 \\ \hline \log T &= 1.21186 \\ T &= 16.288 \text{ sec.} \end{aligned}$$

$$\begin{aligned} \log C &= 0.36282 \\ \log A'' &= 3.05690 \\ \log \tan \varphi &= 9.60859 \\ \text{Const.} \log &= 9.48401 \\ \hline \log y_0 &= 2.51232 \\ y_0 &= 325.3 \text{ m.} \end{aligned}$$

$$\begin{aligned} \log \tan \varphi &= 9.60859 \\ \log B' &= 0.05773 \\ \hline \log \tan \omega &= 9.66632 \\ \omega &= 24^\circ\ 53' \end{aligned}$$

$$\begin{aligned} \log V &= 2.34242 \\ \log u &= 2.81637 \\ \log \cos \varphi &= 9.96686 \\ \text{a.c.} \log 800 &= 7.09691 \\ \log \sec \omega &= 0.04231 \\ \hline \log v &= 2.26487 \\ v &= 184.0 \text{ m.s.} \end{aligned}$$

$$\begin{aligned} \log z_0 &= 3.34329 \\ \log C &= 0.36282 \\ \text{Const.} \log &= 9.48401 \\ \hline \log x_0 &= 3.19012 \\ x_0 &= 1549.2 \text{ m.} \end{aligned}$$

These results are practically the same as those deduced b Siacci's table.

PROBLEM THIRTY-NINE.

Given: The elements of a trajectory. **Required:** Th value of θ for any given value of x.

Solution.—We have*

$$\tan \theta = \frac{\tan \varphi}{A}\left(A - A'\right)$$

In this equation A is either taken from the table with the argument $z = X/C$, or, if X is not given, it may be computed b the equation

$$A = \frac{\sin 2\varphi}{C}\left(\frac{V}{800}\right)^2$$

The quantity A' varies with the abscissa x and is taken from th A' column with the argument x/C.

Example 1.—$C = 1$, $V = 800$ f.s., $\varphi = 5^\circ$. Compute the inclination of the trajectory when $x = 2000$ ft.

By Prob. Two we have $A = \sin 2\varphi = .17365$, and from th table, $A' = .2211$. Therefore

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* *Handbook*, pages 9 and 111.

$$\tan \theta = \frac{\tan 5^\circ}{.17365}(.17365 - .2211)$$

$$\therefore \quad \theta = -1^\circ\ 22'\ 10''.$$

Example 2.—Determine the inclination of the trajectory in both nches when $y = \frac{1}{2} y_0$, with the data of Ex. 1.

We first compute, by Prob. Thirty-six, $y_0 = 71.8$ ft. We have t to compute x' in the ascending branch and x'' in the des-ding branch, for each of which $y = \frac{1}{2} y_0 = 35.9$, by a modifi-on of Prob. Thirty-eight. We have, by substituting Cz for

$$y = \frac{\tan \varphi}{A}(A - a)\ Cz$$

ence

$$(A - a) z = \frac{Ay}{C \tan \varphi}$$

m which to determine z and a by inspection and trial.

In this example we have

$$\log [(.17365 - a) z] = 1.85281$$

the ascending branch this equation is satisfied when $z = 479.5$; d in the descending branch when $z = 2786.4$. The corres-nding values of A' are .0492 and .3200, and the inclinations 3° ' and $-4^\circ\ 13'$. The abscissas x' and x'' have in this case, since e ballistic coefficient in unity, the same values as z above.

PROBLEM FORTY.

To determine the elements of a trajectory for a given projec-e which shall pass through two given points.

Solution.—Let x, y and x', y' be the two given points, and $\varepsilon, \varepsilon'$ eir angular elevations (or depressions) above (or below) the el of the gun. Then

$$\tan \varepsilon = y / x \text{ and } \tan \varepsilon' = y' / x'.$$

From Prob. Thirty-eight we have

$$\tan \varepsilon = \frac{\tan \varphi}{A}(A - a)$$

d

$$\tan \varepsilon' = \frac{\tan \varphi}{A}(A - a')$$

these equations a is to be taken from the "A" column with e argument $z = x / C$, and a' with the argument $z' = x'/C$. lving for A and $\tan \varphi$ we find

$$A = \frac{a' \tan \varepsilon - a \tan \varepsilon'}{\tan \varepsilon - \tan \varepsilon'}$$

and

$$\tan \varphi = \frac{A \tan \varepsilon}{A - a} = \frac{A \tan \varepsilon'}{A - a'}$$

The elements of the trajectory can now be computed as in Probs. Three and Four. It will be observed that all the formulas of this problem are independent of the muzzle velocity.

Example.—$C = 2$, $x = 1800$ ft., $y = 50$ ft., $x' = 2200$ ft., $y' = 10$ ft.

We find $a = .04652$ and $a' = .05722$, whence

$$A = \frac{220 \times .05722 + 36 \times .04652}{220 + 36} = .055715$$

$$\tan \varphi = \frac{.05571}{36 \times .00919} \quad \therefore \varphi = 9° \, 33' \, 30''$$

Next by the formula

$$V = 800 \left(\frac{AC}{\sin 2\varphi} \right)^{\frac{1}{2}}$$

we find

$$V = 466.6 \text{ f. s.}$$

All the other elements can now be computed by methods already explained and illustrated.

By the parabolic theory the expressions for $\tan \varphi$ and V are

$$\tan \varphi = \frac{x' \tan \varepsilon - x \tan \varepsilon'}{x' - x}$$

and

$$V^2 = \frac{g}{2 \cos^2 \varphi} \frac{x' - x}{\tan \varepsilon - \tan \varepsilon'}$$

These formulas give with the data of this example

$$\varphi = 9° \, 49' \, 40''$$
$$V = 452.7 \text{ f.s.}$$

PROBLEM FORTY-ONE.

To determine the elements of a trajectory for a given projectile which shall pass through a given point, with a given inclination.

Solution.—We have as in Prob. Forty,

$$\tan \varepsilon = \frac{\tan \varphi}{A} (A - a)$$

and from Prob. Thirty-nine,

$$\tan \theta = \frac{\tan \varphi}{A} (A - A')$$

Therefore

$$A = \frac{A' \tan \varepsilon - a \tan \theta}{\tan \varepsilon - \tan \theta}$$

and

$$\tan \varphi = \frac{A \tan \varepsilon}{A - a} = \frac{A \tan \theta}{A - A'}$$

A' and a are to be taken from the table with the argument $z = x \,/\, C$.

The corresponding expressions by the parabolic theory are

$$\tan \varphi = 2 \tan \varepsilon - \tan \theta$$

and

$$V^2 = \frac{g\, x \cos \varepsilon}{2 \cos \varphi \sin (\varphi - \varepsilon)}$$

Example.—$C = 2$, $x = 400$ ft., $y = 40$ ft., $\theta = 5°$.

We have $z = 200$, $a = .01011$, $A' = .0203$, $\tan \varepsilon = 01$. Whence $A = .09156$, $z = 1725.5$, $X = 3451$ ft., $V = 726.5$ f.s., $\varphi = 6° \, 24' \, 50''$.

These last two are very important problems in indirect fire.

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PROFESSIONAL NOTES.

ORGANIZATION.

Japan's Army and Navy.

There may and there may not be war in the far East. But whether there is or not, it is well to make a note of the fact that Japan is swiftly coming to the fore as one of the great military and naval Powers not only of the Eastern Hemisphere, but of all the world. She is to-day building more ships and better ships than any other Power, with the single exception of Great Britain, and at the present rate of progress will in a few years rank as the second naval power of the world. This sounds startling, when we remember that at the time of Trafalgar the Land of the Rising Sun was of no more account in the world than the Fiji Islands, and that down to a generation ago it was reckoned a semi-barbarous country. The idea that it will, within the lives of men who remember its "opening," become the rival of the Power that opened it, and of France and Germany, seems like a fairy tale. Yet it is the sober truth.

Japan is now building in England four first-class battle-ships, one first-class cruiser of twenty-three knots, two gigantic armored cruisers of twenty knots and eight torpedo-boat destroyers of thirty knots. In Germany she is building one armored cruiser and eight torpedo-boats, and in France one armored cruiser and four torpedo-boats. In this country she has ordered two cruisers of twenty-three knots, and at home she is building three cruisers, one armored cruiser and three torpedo-boats. At the end of the Chinese war she had forty-three ships, besides torpedo-boats. She will by 1906 have added thereto six battle-ships of about 15,000 tons each, six armored cruisers of 9,200 tons each, five other cruisers, three torpedo gunboats, eleven torpedo-boat destroyers and ninety torpedo-boats. All these will, of course, be of the latest and most approved pattern. An example of their quality is furnished by one of the warships now approaching completion in England, which will be the largest and most powerful battle-ship ever built for any navy in the world, surpassing even the leviathans of Great Britain. It will be 438 feet long and 76 feet wide, with a displacement of 15,240 tons. It will be armored from stem to stern with nine inches of Harvey steel, and its barbettes will have fourteen inches of such armor. Its batteries will include four 12-inch guns, fourteen 6-inch rapid-firing guns and thirty-two smaller guns and five torpedo tubes. Its indicated horse-power will be not less than 14,500, supplied by twenty-five Belleville boilers. That is the sort of craft Japan is getting.

With such a navy Japan will be secure from any invasion of her island home, no matter who may try to succeed where the great Kublai failed. But besides that she will have an army that could give a good account of itself against any that could be sent to that part of the world by any other Power. At the close of the Chinese war the Japanese army consisted of 70,000 men on a peace footing and 268,000 on a war footing. The strength has now been raised to 145,000 and 520,000 respectively, apart from the gendarmerie and militia. That makes a formidable army in size. As for its quality, its conduct in the Chinese war leaves little room for doubt that it will compare favorably with that of almost any other. The Japanese soldier appears to combine dash and spirit with dogged persistence in a remarkable degree. He has all the disregard of pain and death the most fatalistic Chinaman has and the intelligence and discipline of the European. An invading army, supposing it to get past the fleet, would have to cope with a force equal to itself, man for man, and would therefore have to be itself equal to that force in numbers. That any hostile Power will ever succeed in landing half a million men upon the shores of Japan is too improbable for serious consideration.

It may also be observed that these enormous armaments are not costing Japan a ruinous sum. The enlarged army costs for maintenance only some $14,000,000 a year, and the maintenance of the enlarged navy will cost not more than $8,000,000 a year. Of course, the total revenue of Japan is proportionately small, only about $75,000,000 a year, so that this expenditure for army and navy amounts to about 30 per cent of the whole. That is a larger proportion than is spent for such purposes by the United States, Great Britain or France, but not nearly as large as is spent by Germany. Moreover, there is every reason to suppose that the ordinary revenue of Japan will steadily and rapidly increase, so that this war tax will not prove onerous. There is little prospect of the empire falling back in the path it has entered. It is henceforth to be reckoned with as one of the great militant power.

—*New York Tribune*, January 3, 1898.

ARTILLERY MATERIAL.

a. Guns and Carriages.

The construction of modern wire-wound ordnance.

We may take for description the 12 in. gun, as made for the English Government at the Royal Gun Factory, and at Elswick, supplementing our description with other guns of various calibres, and particularly the 12 in. wire guns, eight of which have been constructed for the *Fuji Yama* and *Yashima*, of the Japanese Navy, by Sir William Armstrong and Co., and which vary in several important particulars from the 12 in. English guns, made collaterally with them.

The 12 in. service gun, 1897, consists of a barrel composed of two concentric tubes, known as the inner A tube or liner, and the outer A tube, over which is wound the wire in many layers, passing from one extremity of the gun to the other, and thus distinguishing it from all other guns, which are only reinforced on the breech portion. Outside this again are contracted two very long rather thin hoops and a short connecting collar. The great unstepped length of the chase hoop gives the 12 in. gun a very remarkable appearance. The total length of the gun from breech to muzzle is 445½ in. The weight is 46 tons, about one-quarter of this being taken by the wire, which therefore represents a length of about 100 miles.

The Japanese 12 in. gun is only strengthened with wire at the rear half, about five tons of wire being used. The arrangement of the chase hoops has, therefore, to be different to the English gun to give the necessary strength. The very long hoops cannot in consequence be conveniently used, and two shorter hoops with a stepdown are therefore employed. A double barrel is not used in this gun.

The English specification for gun steel is as follows, an alteration in one or two points having been made within the last eighteen months :—

"Tensile test pieces for gun forgings.

Breaking strains.		Elongation.
Tons per square inch.		Per cent.
Not less than	Not more than	Not less than
34.	44.	17.
Tensile test pieces for breech screws. Breech-bushes aud axial vents (obturators).		
38.	48.	15.

"Each test piece before testing is to be provided with two gauge points accurately adjusted to 2 in. apart, and is to be subjected in the testing machine, in the first instance, to a load of 21 tons per squre inch; should the machine record any yielding point before this load has been reached, the same is to be noted. The load is then to be entirely removed, and the test piece measured. The permanent elongation under the load of 21 tons per square inch is not to exceed 0.02 in. The load on the test piece is then to be again applied until the breaking point is reached. The bending test pieces are to be pressed flatways with a semicircular-ended presser, through one or more suitable apertures or guides, furnished or not furnished with anti-friction rollers, at the option of the contractors or makers of the steel. That flat side of the test piece which was the nearer to the centre of the gun is to be, in each case, in contact with the presser.

"This test is to be borne without the outer surface of the steel exhibiting an open crack across the whole of its width. Diameter of end of presser is to be 1.5 in., and the width of apertures, or between the guides, 2.375 in." Each tensile test piece is 4½ in. long, having a cylindrical central part 2 in. long by 0.533 in. diameter. The bending test pieces are 4½ in. long, by 0.75 in. wide, and 0.375 in. thick.

A clause is also included in the specification that all pieces which are to be ultimately pierced with a hole greater than 6 in. in diameter must be forged on a mandril, leaving a hole reasonably near to the finished size through them. Every tube, therefore, on the 12 in. gun has to be forged in this manner. The forgings are made from cast steel ingots of particular shape. They are octagonal truncated cones, superposed on a short abrutly-tapered circular base. The narrower part of this ingot is the top, and as it in consequence contains the light impurities, a great part of it, about one-third of the whole ingot, has to be cut away. The circular base is also removed. The machines used for cutting the ends off at Elwick are admirably adapted to the work. They were made by Messrs. Craven Brothers, Manchester. Each machine consists of a heavy vertical circular face-plate, rotated by a powerful worm. On this face are two flat steel cheeks, from 1 in. to 1½ in. thick, capable of movement towards each other. Let into the edges of these cheeks are the cutting tools. The action is obvious. A simple automatic gear moves the cheeks nearer and nearer together, and so feeds the cut. Sometimes superposed above the first pair of steel plates is a second similar pair so arranged that a suitable slice from which to cut test piece is ripped off. The ingot either passes through a hollow head or is supported in front only. Three large V blocks carry it. The defective material having been removed, a test of the steel for the maker's satisfaction is taken from the slice removed, which is, of course, adjacent, and practically the same as the corresponding face of the material to be used. This proving satisfactory, the ingot is then trepanned. As every one knows, a trepanning machine has a hollow instead of a solid boring bar, and the cutting tools attached to the end face of the bar, so that a circular cut is made, and as the work advances a solid core of steel enters the bar, and is, of course, available for future use. It is very rarely necessary to trepan a large hole in an ingot. As the ingot is short, and the piece to be made from it is long, the whole substance is as a rule required, so that only a sufficiently large hole to insert a mandril powerful enough to carry the ingot is pierced.

Of late years hydraulic, or pressure forging, has almost entirely superseded hammer forging for gun work. Of course, where large hammers have been put down at great expense they are still used; but no new large hammers are now built. The effect of the press on the steel is far superior to that of the hammer. With the latter the material is acted on superficially, the tendency being, as anyone who has watched a large hammer at work on a rectangular block will have noticed, to increase the area of the surface struck disproportionately to the body of the material. With the press a reverse effect obtains; a rectangular block bulging at the sides being produced, but at the same time, the disproportion between the action on the substance and the face is less than with a hammer. For heavy work a very great hammer pressure is, of course, required, presses acting at from 2000 to 5000 tons being not uncommon, and they are usually fed at a very high pressure. The ingot is heated in an immense furnace, usually by producer gas, and when hot is lifted out on the mandril by hydraulic cranes. The mandril is slightly tapered and is hollow, a copious stream of water passing through it continuously. Near one end of it is attached a large head, and between the head and the ingot a large block of metal slides on a parallel bar, or portion of the mandril. To remove the mandril, ropes or chains are attached to this block. A few men then draw it forwards towards the ingot, the ingot resting on the anvil at the time, and a great number of men draw it back smartly against the head of the mandril. The mandril is thus hammered out till the taper allows it to be removed freely.

The hydraulic forging press is always vertical; the head is rectangular and flat-faced, but the anvil for circular work has a large triangular notch, which not only keeps the work truly in place as it is turned round and round, but distributes the pressure in the most effective manner. For revolving a large ingot or forging it is usual to attach to the end of it a great ratchet wheel with a lever and pawl worked by a chain from an hydraulic cylinder. The metal to be worked rapidly has to be intensely hot; but, as in the earlier stages of working up from an ingot, the metal is collected into a short length, and is consequently very thick, it retains its heat for a long time. The forgings for the barrel of the 12 in. English gun are about 43 ft. long, and for the Japanese gun some 5 ft. longer. Some surprise will, perhaps, be felt that such a great length of such small internal diameter, between 9 in. and 10 in., can be forged hollow satisfactorily; but it may be mentioned that failures are rare, and that much longer hollow forgings for steamship are not infrequently made.

—*The Engineer*, January 21, 1898.

b. Armor and Projectiles.

* * * * *

c. Powder and Explosives.

High explosives and modern war vessels.

It is now an acknowledged axiom that high explosives will be employed in shells. Whether naval officers object to carry them on board ship or not, they will in future be the principal ingredient by which shells are filled for coast and siege purposes; and already the nature of high explosive to be used as a "service" bursting charge for high angle howitzers in coast and siege batteries has been practically determined.

After exhaustive trials, all inventions in this direction, except wet gun-cotten and lyddite, have been discarded. A satisfactory high-explosive has been defined as fulfilling the following conditions:—"It should be safe in manufacture, store, and transport, and stable under service conditions. It should be of a convenient form for filling shell, and safe to manipulate in the process. It must be capable of standing the shock of discharge in high-velocity guns, and must on striking detonate with violence and certainty, and without the aid of any dangerous fulminate. The explosive should be capable of having its sensitiveness increased or diminished as occasion may require, and a shell, when filled with it should not detonate when hit by another shell." "Of those high explosives experimented with, the two coming nearest to the standard are wet gun-cotton, which has been adopted by at least one European Power, and lyddite, which is used in our service." Wet gun-cotton will not detonate in a shell struck by another shell, and in this respect is more satisfactory than lyddite; but gun-cotton, to produce its best effect, must be compressed into discs to fit the interior of the shell, and the shell must therefore be made in two parts and screwed together—a source of weakness and possible danger. Dry cotton and a fulminate are, moreover, required to detonate it. Hence lyddite, to whicn none of these objections apply, will probably be adopted as the high explosive of our service.

Such being the case it is interesting to note the character and appearance of lyddite. Under the name of picric acid it has long been known. Picric acid is a nitro-substitution compound obtained by the action of nitric acid on a variety of substances; for example, indigo, silk, acaröid resin, etc., but on the commercial scale the substance now generally acted on by the nitric acid is carbolic acid, and the equation of the process is simple, viz.:—

$$\overset{\textit{Carbolic acid.}}{C_6H_6O} \quad + \quad \overset{\textit{Nitric acid.}}{3\,H\,N\,O_3} \qquad \overset{\textit{Picric acid.}}{H\,.\,C_6\,H_2\,.\,3\,N\,O_2\,.\,O + 3\,H_2\,O\,.}$$

Picric acid may, as written above, be regarded as a picrate of hydrogen, which latter element can be displaced by a metal to form an ordinary picrate —for instance, picrate of potassium, $K\,.\,C_6\,H_2\,.\,3\,N\,O_2\,.\,O$. It is a crystalline substance of a brilliant yellow color. and is intensely bitter to taste. It burns with a very smoky flame. It is largely used as a dye, or constituent of dyes, and has not been usually considered as an explosive. Nor, indeed, does it usually behave like an explosive under ordinary circumstances, though under special conditions easily produced, it is capable of developing its now well-known formidable explosive properties. It may be burnt away in an unconfined state in considerable quantity without explosion, but the mere contact of certain metallic salts or oxides with picric in the presence of heat developes powerful explosives which are capable of acting as detonators to an indefinite amount of the acid, wet or dry, which is within reach of their detonative influence.

Lyddite has proved to be a fairly stable compound, and safe in manufacture, store and transport. High temperatures aboard, or in ships' magazines, do not affect its condition. When carefully packed into shells it does not "set back," like the nitro-glycerine in dynamite, on the shock of discharge, and so interfere with the "exploder." or create a condition of extreme danger, from the likelihood of a premature. Several accidents have occured during the fire of shells charged with lyddite, from this last-mentioned cause, viz., the projectile prematurely exploding in the bore of the gun. But in the majority of cases the causes of the disaster were traced to faults in the shell, and were not due to over-sensitiveness of the lyddite. Shells to contain it are now made of the best forged steel, which minimises the prospect of prematures. The action of a powder fuze will not detonate lyddite, hence an exploder containing a few ounces of a safe and stable explosive is employed. It is inserted in a hole drilled centrally in the charge. The actual nature of the exploder used by the War Department is kept secret, but many metallic oxides and nitrates will detonate when brought into contact with picric acid at a high temperature, and this fact has probably been taken advantage of by the chemical department.

Clearly, then, the high explosive shell has a very marked future before it, for artillery fire or active service; and, as foreign Governments have gone even further than we have in the development of this terribly effective projectile—for one European navy, at least, has already introduced the mélinite shell into its magazines on board ship—we must be prepared for attack with high explosive shells in the next naval action, not only from shore batteries, but from the enemy's vessels.

This is a serious outlook. Take the cases of the *Majestic*, *Powerful*, or *Diadem* types. Probably the 6 in. Harveyised steel armor plates upon the 6 in. gun casemates of these vessels would break up or explode outside the majority of high-explosive shells with which they might be attacked, and the side and barbette armor would certainly be sufficient to effect this desirable end; but the whole of the upper deck battery would be at the mercy of a few high-explosive shells which should burst within it, either from contact with a 12-pounder mounting or any other cause, and the whole of the main deck space from stem to stern, except the eight closed-in casemates, including the entire series of officers' cabins, would be mere shambles in a quarter of an hour. If anyone doubts the probability of this, let him go over the *Resistance* and judge for himself. She is an object lesson, the value of which cannot be controverted.

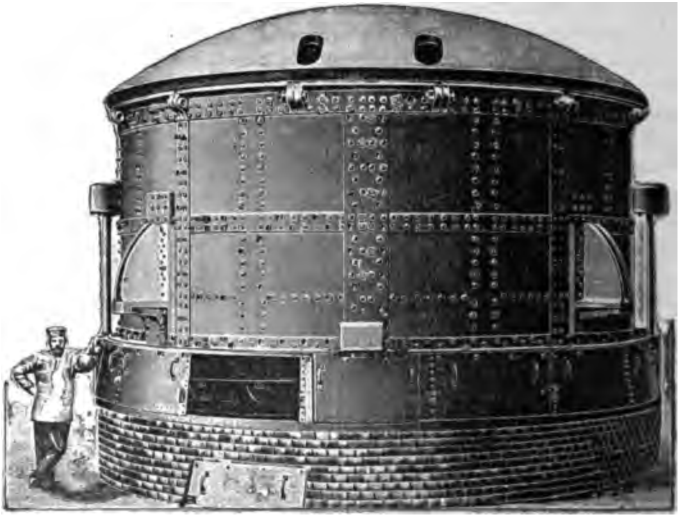
But, it may be asked, is there any remedy for such a condition of terrible insecurity as regards the officers and crews of our war vessels in the future should the high-explosive shell do all that is expected of it? We believe that there is a partial remedy, but we fear not one that will commend itself in the eyes of our naval constructors. Looking at the *Powerful* or *Diadem*, the enormous freeboard given to these types cannot but excite observation. Is it excessive or not? That is the question. We cannot help thinking that, in running away from the evils of low freeboard, we have now run into the opposite extreme, if only the casemates can be adequately protected with armor against high-explosive shells, whilst vessels of so high a degree of freeboard are being built. We would cut them down in future and utilise the saving in weight of material thus released to provide a more extensive system of armor protection over the reduced surface of the ship's sides. As the *Powerful* and *Diadem* types are at present they are merely huge targets, which will be the sport and pastime of an energetic enemy, who may possess guns firing high-explosive shells; their only chance in action would be to at once crush their enemy with their own high explosives, or run away and trust to the diminishing perspective of their form as they disappear over the horizon for the chance of not being hit. As regards our battleships, it is difficult to suggest anything; but surely a *milieu* could be designed between the *Nile* and *Trafalgar* which possess almost perfect immunity from the chance of destruction between decks by high-explosive shells, and the *Majestic*, which has none whatever above the main deck. Here is food for reflection.

—*The Engineer*, December 24.

FORTIFICATION.

Armored Cupola for Fort Wealhem, constructed at the Ateliers de Construction de la Meuse, Liège.

Belgium for centuries enjoyed the doubtful dignity of being the cockpit of Europe, and its people are far from anxious to repeat their previous experiences in this line. It is true that the independence of the Belgian soil is under international guarantee, but in cases of emergency such safeguards are too likely to prove illusive, and the campaign of Ulm furnishes a precedent for the violation of neutral territory, if great strategic advantages are to be gained thereby. Belgium has accordingly deemed it prudent to reinforce such protection as is afforded by treaty by the establishment of a formidable series of modern forts, equipped with heavy guns fixed in an armored turret or cupola of the type originally introduced by General Brialmont. One of these cupolas, constructed by the Ateliers de Construction de la Meuse, Liège, is illustrated above, and photographs of it were shown at the Brussel Exhibition. The cupola differs from a ship's turret in the fact that the body being sunk in a pit, the sides do not require armoring, whilst the top, being domed, it is very unlikely to be struck a fair blow by an enemy's projectile. Experience has shown very conclusively the great resisting power of inclined armor. The particular cupola illustrated has been built for the Waelhem fort, and takes two 150-centimetre (5.9 in.) guns. Very complete tests of the plant were made by the authorities last December and January. One hundred rounds were fired from the guns with full service charges, each charge comprising 19.8 lb. of brown prismatic powder, and a shell weighing 108 lb. At the conclusion of the trial the whole of the working parts, including the springs for



taking up the recoil, were found in excellent condition. It was ascertained, moreover, that the guns could be trained through 27 deg. in from 25 to 30 seconds. Special attention has been devoted to the ready mounting and dismounting of the guns, one of which can, it is found, be removed and replaced in 65 minutes. The cupola can be rotated at the rate of one complete revolution in 60 seconds, when six men are employed to work the turning gear; four men, it was found, could make a turn in 75 seconds, and two men in 150 seconds.

Engineering, December 24, 1897.

MILITARY GEOGRAPHY.

Hawaii.

LOCATION.

The Hawaiian Islands are near the middle of the North Pacific Ocean, between 18 and 22 degrees North Latitude and 154 and 160 degrees West Longitude.

The following map shows their position, better than any description.

Without disputing Boston's claim to be the hub of the Universe, Hawaii is the hub of the Western Hemisphere.

STRATEGICAL POSITION.

Hawaii is the only spot in the Pacific, from the Equator on the South to Alaska on the North, and between America on the East and Asia on the West, where water, food or coal can be obtained. It is also on or near the principal trade routes across the Pacific. Its unique position is what has given it the name of "*The Cross Roads of the Pacific*," "*The Key of the Pacific*," and "*The Gibraltar of the Pacific*."

CAPTAIN MAHAN'S OPINION.

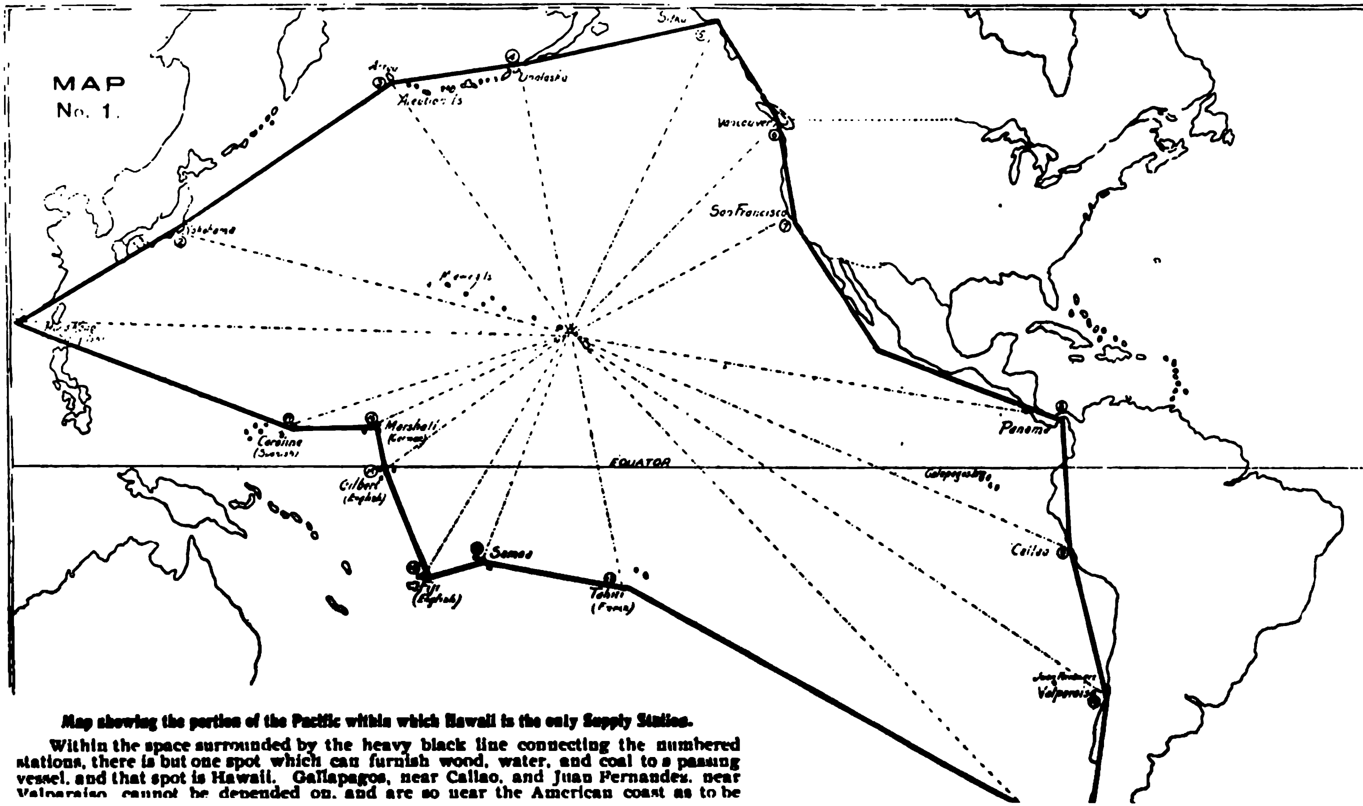
Captain Mahan, of the U. S. Navy, one of the highest authorities on naval strategy, says that Hawaii is one of the most important strategical points in the world; that it stands "alone, having no rival and admitting no rival."

The distances to the principal Pacific ports are as follows:

Hawaii	to	San Francisco	2080	Miles.
"	"	Nicaragua Canal	4210	"
"	"	Tahiti	2389	"
"	"	Pagopago, Samoa	2263	"
"	"	Auckland, New Zealand	3850	"
"	"	Fiji	2736	"
"	"	Marshall Islands	2098	"
"	"	Caroline Islands	2602	"
"	"	Hong Kong	4917	"
"	"	Yokohama, 'apan	3399	"
"	"	Unalaska, Aleution Islands	2016	"
"	"	Sitka	2395	"
"	"	Vancouver	2305	"

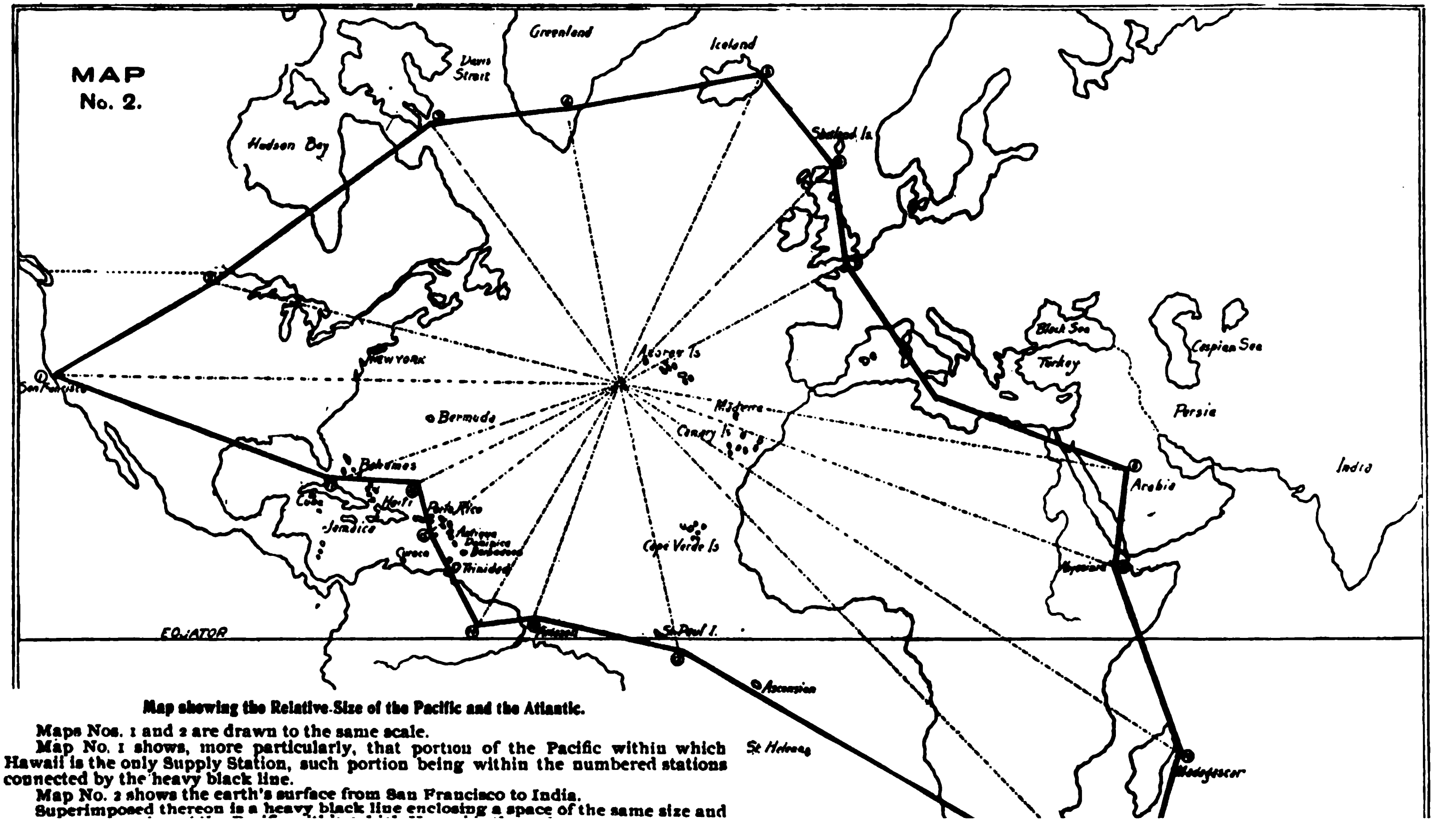
NUMBER AND AREA OF ISLANDS.

The group contains eight inhabited islands and a large number of small uninhabited ones, of a total approximate area of 7000 square miles, or 4,480,000 acres; being nearly the area of Massachusetts, and considerably larger than Connecticut and Rhode Island combined. The group extends east and west a distance of 1200 miles. The eight principal islands cover 300 miles at the eastern end of the group. They are Ha-wai-i, Mau-i, O-a-hu, Kau-ai, Mo-lo-kai, La-nai. Ka-hoo-la-we and Ni-i-hau. There are valuable guano and phosphate rock deposits on some of the western islands.



Map showing the portion of the Pacific within which Hawaii is the only Supply Station.

Within the space surrounded by the heavy black line connecting the numbered stations, there is but one spot which can furnish wood, water, and coal to a passing vessel, and that spot is Hawaii. Gallapagos, near Callao, and Juan Fernandez, near Valparaiso, cannot be depended on, and are so near the American coast as to be



Map showing the Relative Size of the Pacific and the Atlantic.

Maps Nos. 1 and 2 are drawn to the same scale.

Map No. 1 shows, more particularly, that portion of the Pacific within which Hawaii is the only Supply Station, such portion being within the numbered stations connected by the heavy black line.

Map No. 2 shows the earth's surface from San Francisco to India.

Superimposed thereon is a heavy black line enclosing a space of the same size and

HO-NO-LU-LU.

Situated on the island of O-a-hu, is the principal city and the capital of the Republic.

It is located on a small but safe harbor, and has a population of 30,000.

The business portion is well built of stone and brick; the residences are of wood.

The city has 67 miles of street and drives, of which 20 miles are macadamized; has a street railway system; public and private electric light system; a telephone system extending throughout the island and using 1300 telephones; a well regulated State prison; handsome executive buildings, Custom House and Court House; an Insane Asylum, Public Hospitals, Maternity House, Old Folks Home; Public Library; a well equipped Y. M. C. A. building; banks; churches; public and private schools; public water works, both a reservoir and pumping plant; a paid fire department equipped with the most modern steam and chemical engines; has a G. A. R. Post; branches of the Societies of "Sons" and "Daughters" of the American Revolution, and numerous Masonic, Odd Fellows and other similar Lodges. In other words, it has the appliances and conveniences of an up-to-date American city, with the added charm of a profuse tropical vegetation, and a climate unrivalled the world over for mildness and evenness.

The city lies on a level strip of land along the sea, a mile or two wide and five miles long, and extending back for several miles into five valleys, which cut deep into thickly wooded, cloud-capped mountains rising to an elevation of nearly 4000 feet at a distance of six miles from the sea.

GENERAL PHYSICAL CHARACTERISTICS OF THE COUNTRY.

The islands are all high and mountainous, rising to a height of 4000 feet on Oahu, to 10,000 on Maui, and 14,000 feet and perpetual snow on the island of Hawaii. The whole country is volcanic in origin, there being hundreds of extinct and two active volcanoes.

Each island consists of one or more mountains seamed with valleys and gorges, with rolling plains lying between the mountains, and generally fringed with a comparatively level belt along the sea shore.

Some portions of the coast are protected by reefs of coral, while others are sheer precipices rising out of blue water to a height of thousands of feet.

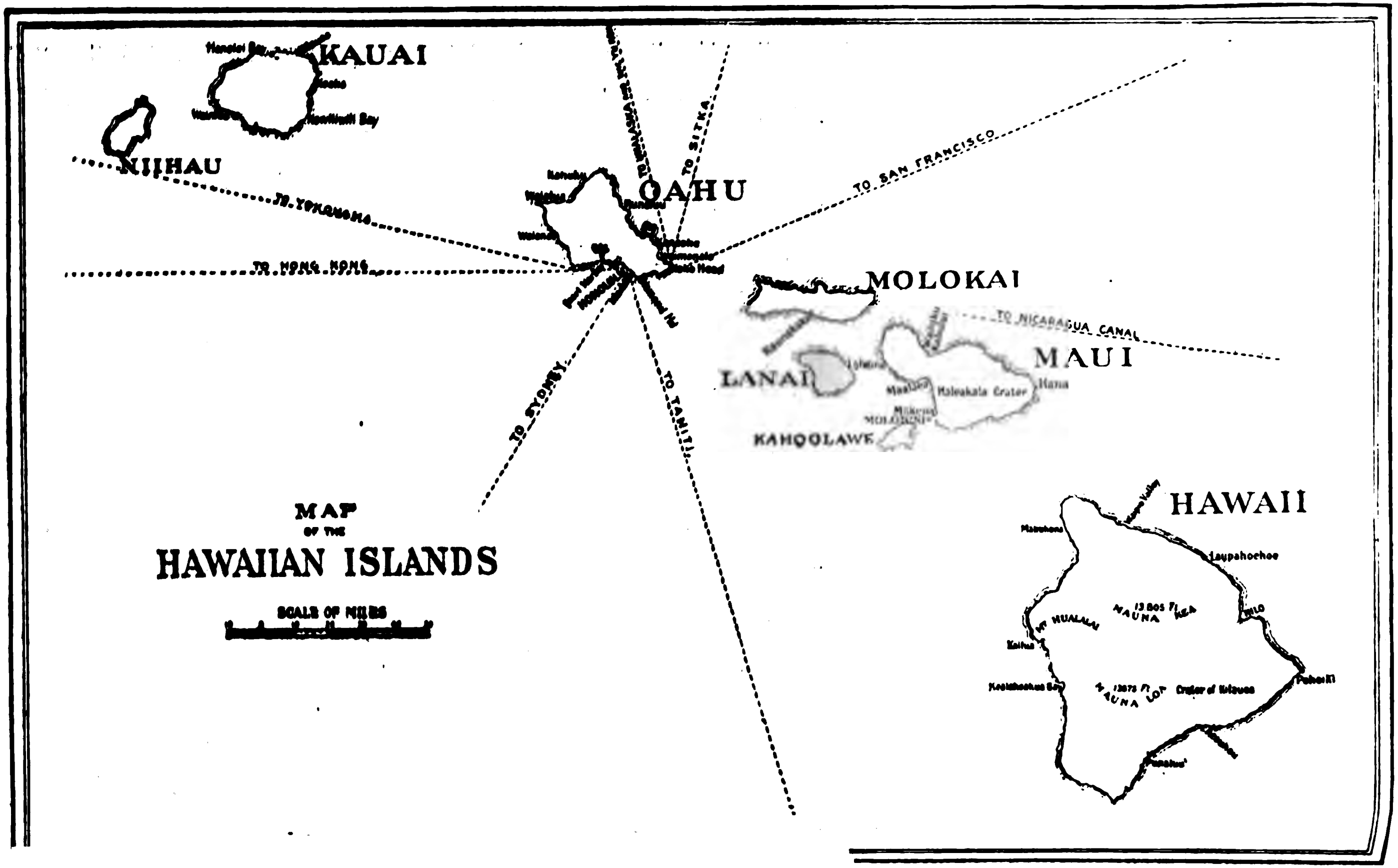
The Soil, consisting of decomposed lava, is fertile; but has to be irrigated in many places, the water coming from mountain streams, artesian and surface wells. Some of the largest steam pumps in the world are used, raising water to an elevation of 400 feet.

Fertilizers are used in large quantities, thousands of tons per annum being used on the sugar plantations.

The Climate, is mild and even, being of an average weekly maximum of 74 in winter and 82 in summer. There are no extremes of heat or cold. The lowest temperature at sea level in winter, is about 56° and the hottest in the summer about 88°. A temperature of 90° in the shade is almost unknown. At higher elevations above the sea almost any desired temperature can be found. On two mountains there is perpetual snow.

The cool northeast trade winds blow for nine months of the year. Except when the south winds blow the humidity of the air is low.

The country at all elevations, and throughout the year, is healthy, the death rate among whites being exceptionally small. None of the fevers and other



MAP OF THE HAWAIIAN ISLANDS

typical diseases of tropical countries are found there, and the diseases of the temperate zone are usually of a mild character.

The climate is so balmy and natural conditions so delightful that, by common acceptance, Hawaii is known as "The Paradise of the Pacific." Although spoken of as a "tropical country" it is barely on the edge of the tropics, and the same Arctic current that cools San Francisco gives Hawaii a climate many degrees cooler than in the same latitude in the Atlantic. It is a climate well suited to the physical and mental development of the Anglo Saxon.

Products. The principal products are sugar, rice, coffee, bananas, pine apples, guavas and other tropical fruits, many of which grow wild.

Sugar. The area cultivated with sugar cane is approximately 80,000 acres. The export of sugar in 1896 amounted to 221,000 tons. The output of sugar cannot be much increased, as most of the sugar lands are already occupied.

Coffee. The cultivation of coffee is rapidly increasing. It will soon rival sugar in amount and value, as there are large areas of rich but yet uncultivated land, not available for sugar but peculiarly adapted to coffee. This product is the hope of the country, as it can be produced profitably by farmers with small capital.

Bananas and Pine Apples. The principal supply of these fruits consumed on the Pacific Coast is from Hawaii. It is a growing trade.

The Rainfall varies greatly, ranging from fifty inches in some districts to 175 inches in others. Irrigation supplements the rainfall in the dryer section. Two-thirds of the sugar is produced by irrigation.

Education. There is a highly organized system of free public schools, modeled on that of the United States, in which the English language is taught. There are also a number of private boarding schools, and schools ranking with high schools in the United States.

The public school year is eight months, and all children between six and fourteen years of age are compelled, if physically able, to attend school.

All the Hawaiian born population of all nationalities can read and write English. The number of schools in 1896 was 187; number of teachers 426; number of scholars 12,616.

The schools are under the control of an unpaid board of five persons, appointed by the President.

The constitution prohibits the appropriation of public funds for sectarian or private schools.

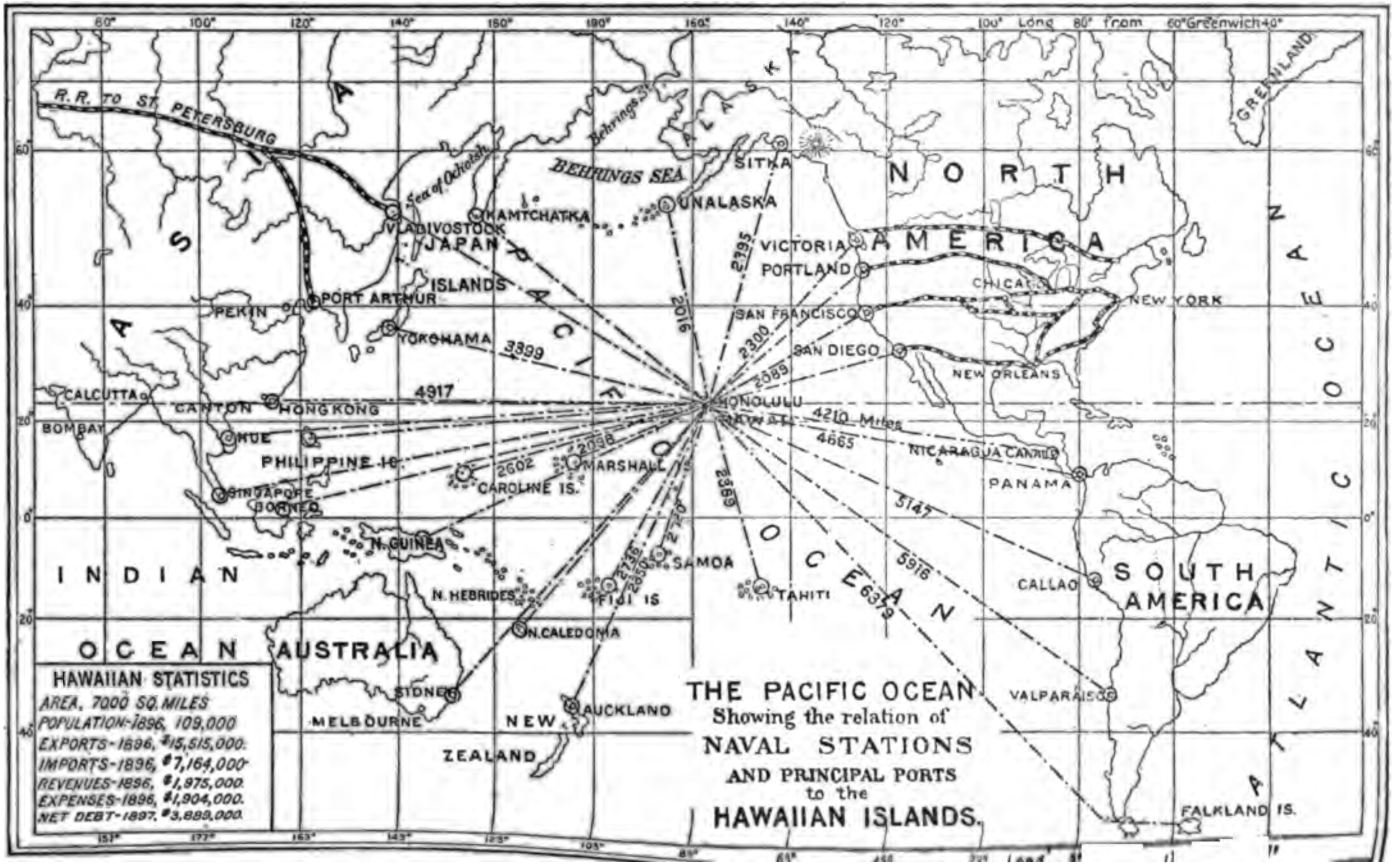
The question is frequently asked, how the possession of Hawaii, 2000 miles distant from the continent, will secure control of the North Pacific, and why Hawaii is more necessary to the Pacific Coast than are the Azores, which are about the same distance off the Atlantic Coast, necessary to the protection of the United States on the Atlantic side?

The reasons why Hawaii is essential to the protection of the Pacific Coast, and why the Azores are not necessary to the protection of the Atlantic, are as follows:

In the first place, the distance across the Atlantic is approximately 3000 miles.

The distance across the Pacific is from 7000 to 9500 miles.

Second: All of the Great Powers of Europe lie, or have coaling stations, within steaming distance of the Atlantic Coast of the United States. On the other hand no nation, European or Asiatic, lies, or possesses a coaling station, near enough to the Pacific Coast to be practicably available, as a base of hostile naval operation against that Coast or its commerce.



THE PACIFIC OCEAN
Showing the relation of
NAVAL STATIONS
AND PRINCIPAL PORTS
to the
HAWAIIAN ISLANDS.

HAWAIIAN STATISTICS

AREA, 7000 SQ. MILES
POPULATION-1896, 109,000
EXPORTS-1896, $15,515,000.
IMPORTS-1896, $7,164,000.
REVENUES-1896, $1,975,000.
EXPENSES-1896, $1,904,000.
NET DEBT-1897. $3,889,000.

British Columbia is not a material factor in this connection; for, in case of hostilities between England and the United States, all Canadian territory would be so speedily overhelmed by invasion from the United States that its ports would not cut any material figure as hostile bases of operation for any considerable length of time.

Third: On the Atlantic there are scores of islands which can be used as bases of naval supply and repair. There are not only the Azores, Madeira, Canary, Cape Verde, Bermuda, Newfoundland, and the Bahamas, but the vast number of West India Islands.

On the other hand; in the whole Pacific Ocean from the Equator on the South, to Alaska on the North; from the Coast of China and Japan on the West, to the American Continent on the East, there is but one spot where a ton of coal, a pound of bread, or a gallon of water can be obtained by a passing vessel, and that spot is Hawaii.

The immensity of this area of the earth's surface is comprehended by but few.

The distance from Hong Kong, through Hawaii to Panama, is 9580 miles. This distance is as far as from San Francisco eastward across the continent, across the Atlantic, across the Mediterranean, and across Turkey to the boundary of Persia.

The first supply station north of Hawaii is at Unalaska in the Aleution Islands, and the first similar station on the south is Tahiti, a French Colony.

The distance between Unalaska and Tahiti is 4400 miles; as far as from the southern point of Greenland to the mouth of the Amazon river.

The Atlantic is, comparatively, so narrow, that way stations are not absolutely essential; while the islands in the Atlantic north of the Equator, capable of use as way stations are so numerous that it is practically impossible for the United States to absorb them all.

On the other hand, the width and size of the North Pacific is so great that no naval vessel in existence can carry coal enough to cross the Pacific from any of the existing or possible foreign naval stations, to the Pacific coast of the United States, operate there and return, without recoaling. A modern battleship without coal is like a caged lion—magnificent but harmless.

One of the first principles in naval warfare is, that an operating fleet must have a base of supply and repair.

Any country in possession of Hawaii would possess a base of operations within four or five days steaming distance of any part of the Pacific Coast.

Without the possession of Hawaii, all of the principal countries possessing interest in the Pacific, are so far away that the distance is practically prohibitory of hostile operations against the Pacific Coast. For instance, the nearest English station is forty-six hundred miles distant from San Francisco. The nearest French station is thirty six hundred miles distant. The nearest Spanish station is forty-seven hundred miles distant. Russia is forty-seven hundred miles away; Japan forty-five hundred miles, and China fifty-five hundred miles.

The United States, in possession and control of Hawaii, will thereby, by simply keeping other nations out, afford almost absolute protection on her Pacific Coast and commerce from hostile naval attack. On the other hand, Hawaii, in possession of any foreign country, will be a standing menace against, not only the Pacific Coast, but against all of the Ocean-bound commerce to and from that Coast, and all American commerce on or across the North Pacific.

ɔf Hawaii to the commerce of the Pacific is
ted by t that seven trans-Pacific steamship lines plying
Continent and Japan, China and Australia, all
nol a way n.

above set for that Hawaii has for the last fifty years
and Naval Authorities as "The Key of the
" and A rican tesmen, regardless of party, have con-
and pe d the policy that the United States could
y fore people to colonize or control Hawaii.

ne o Nica or Panama Canal, practically all of the
bound use thereof, will stop at Honolulu for coal

s to , y of the American merchant marine engaged
or le.

er of ering American ports during the year
30, :

From U	Kingdom	88
Fr	ia, Africa, Australia, and Oceanica combined	210
Fr		191

other ii furnished cargo for 191 American ships, and all
of the American continent, furnished cargo for only
s.

nabit oppose annexation of Hawaii, to ridicule the
y of any taking any action in or towards Hawaii
the the United States.

of judging the future is to examine the past.
thin nty-five years, Hawaii has been taken possession of:

Once by Russia.
Once by England.
Twice by France.

And by reason of hostile demonstrations by foreign governments, creating the fear of foreign conquest, an absolute cession of the sovereignty of the country to the United States was executed and delivered in 1851, and a treaty of annexation negotiated in 1854.

Since 1874, on four separate occasions, internal disturbances have required the landing of foreign troops from war ships, for the protection of the interests of the several nations there represented.

During the past few years there has not seemed to be any likelihood of conflict between the United States and any other foreign powers, and many persons have concluded that there is no possibility of conflict in the future.

While the tendency of the age is undoubtedly in favor of arbitration and against war, the existing conditions in the world are not such as to guarantee that the millennium is near at hand, and more particularly are the developments in the Pacific such as to render it unsafe for any country possessing interests therein to act upon the supposition that there will be no conflict of interests in that locality.

Russia has heretofore been a European country, with but a nominal interest in the Pacific. Within the past five years it has developed Pacific wards, until it fills the northwestern horizon, and with the now rapidly progressing development of its vast empire on the Pacific coast of Siberia; the construction of its transcontinental railway from St. Petersburg to the Pacific, and the fore-shadowed absorption of northern China, there can be no prediction of the limit of its interests and strength in the Pacific.

The meteor-like projection of Japan into the international sky, is too recent and vivid to need any enumeration of detail. In the short space of a year Japan has become not only a Pacific, but a world power.

With its rapidly increasing population, already numbering nearly fifty million; its navy now stronger than any other in the Pacific; its demonstrated power of organization and military execution; its progressive commercial and aggressive national spirit, there is no safety in basing any calculations upon the meekness or weakness of Japan.

Whether the government of Great Britain will voluntarily engage in hostilities with the United States, may be doubted; but there is a great Anglo-Saxon community growing up in the Pacific, including Australia, New Zealand, and hundreds of islands within their sphere of influence, whose interests are so great as to radically affect and frequently control British policy. This great Anglo-Saxon community inhabiting a country larger than the United States, excluding Alaska, is in the spring tide of its development. Its leading statesmen have repeatedly and publicly advanced the claim that the control of the Pacific was theirs, by right. Today, their influence and strength is not sufficient to be a serious menace to other interests in the Pacific. What their power may be fifty, or a hundred years from now, no man can tell. The statesmen of the United States should look, not to the condition of today only, but should stake out and secure to the United States the position and policy which that country may require for a hundred years to come.

—*Shall Hawaii be Annexed. L. A. Thurston.*

The new Concrete and Steel Government Docks at Puerto Cabello, Venezuela.

A concrete and steel dock of rather novel construction was completed during the past summer at Puerto Cabello, a harbor on the Caribbean Sea, about 80 miles west of Caracas, Venezuela. Puerto Cabello is the second port in commercial importance and probably the first in natural and geographical advantages in the republic of Venezuela. It is situated on a peninsula, the northern extremity of which forms the wharf front where the new dock has been built. Lying to the north and east of the port are several islands connected by coral reefs, which form a natural breakwater, behind which lies what is called the inner harbor. This inner harbor is reached by traversing a bay several miles in extent and having a depth of water of from 60 to 100 ft. Owing to the natural protections the waters of the bay and harbor are always tranquil, and from this fact comes the name Puerto Cabello, or "port of hair," by which the early Spanish sailors strove in a rather fanciful way to commemorate the fact that they could anchor their vessels by a hair and have them ride safe from storm.

The construction of the new dock has proceeded with true tropical leisure; work having being begun in February, 1885, and completed in July, 1897. The extreme length of the dock is 450 m. (1,476 ft.), and it consists of a steel and concrete platform supported on steel piles. The portion of the platform intended for vessels of heavy draft is 8 m. (26.24 ft.) wide and 2 m. (6.54 ft.) above high tide, and the portion intended for vessels of light draft varies in width from 4½ m. to 6 m. (14.76 ft. to 19.68 ft.) and is 3.22 ft. above high tide.

A retaining wall was first built along the shore to hold back the sand. This wall is supported on timber piles 30 cm. (0.98 ft.) in diameter driven 6 m. (19.68 ft.) into the bottom, and is 6 m. (19.68 ft.) high, 3 m. (9.84 ft.) wide at the bottom, 75 cm. (2.46 ft.) wide at the top and is vertical on the face and battered on the back. Parallel to this wall and 2.65 m. (8.69 ft.) from its face was driven a row of steel piles 20 cm. (0.65 ft.) in diameter. The piles are spaced 7 m. (22.96 ft.) apart c. to c. A second row of piles, also spaced 7 m. apart, and 3 m. (9.84 ft.) from the first row, was next sunk. The piles in this last row are 30 cm. (0.98 ft.) in diameter. The piles in each row are connected by I-beams resting in U-shaped caps fastened to the tops of the piles, and the two rows of piles are braced together by I-beams bolted to the main I-beam stringers. All this metal work was protected before erection with a coating of magnetic oxide, then an enamel coating and finally three coats of oxide of lead paint, and after erection it was covered with an armor of Portland cement mortar.

The steel piles were composed of hollow tubes fastened together by collar joints. The bottom section carried a pointed shoe and the top section carried the U-shaped socket casting previously mentioned. The method of sinking was to connect a sufficient number of sections on shore to bring the top of the pile well above water when lowered and then to drive the pile with a pile driver, adding new sections as the pile descended. Generally the piles were driven about 13 m. (42.64 ft.) into the bottom, which consisted of decomposed shell detritus mixed with mud. After the driving was completed a diver fastened a disk 1 m. (3.28 ft.) in diameter to each pile close to the bottom and a few blows were then given the pile to settle the disk firmly on the bottom. The hollow interior of the pile was then filled with concrete, and the cement mortar casing was built around the outside. To place this casing an iron cylinder composed of sections and 80 cm. (2.62 ft.) in diameter was slipped over each pile and the annular space filled, using shovels with long handles, when the depth of water was not very great, and a sort of tongs terminating in a closed box when the depth was over 4 m. (13.12 ft.). These tongs kept the mortar away from the water and enabled it to be placed without danger of washing the cement away.

The I-beam framework of the platform was also protected by a cement mortar casing. For the casing under water a composition of one part cement and one part sand was used, and for that above water the composition was one part cement and two parts sand. The frame work of concrete and steel was covered with a plank floor.

This system of concrete and steel dock construction is, it is stated, the invention of the firm of N. A. Paquet & Co., of Caracas, Venezuela, who were the contractors for the dock at Puerto Cabello. Mr. Thomas Llamozas was chief engineer of the work, which was carried out by the Venezuelan Government, at a cost of 1,900,000 bolivars, or about $1,543,000. For the information from which this description has been prepared we are indebted to Mr. S. W. Casartelli, of Caracas, Venezuela.

Engineering News, December 23, 1897.

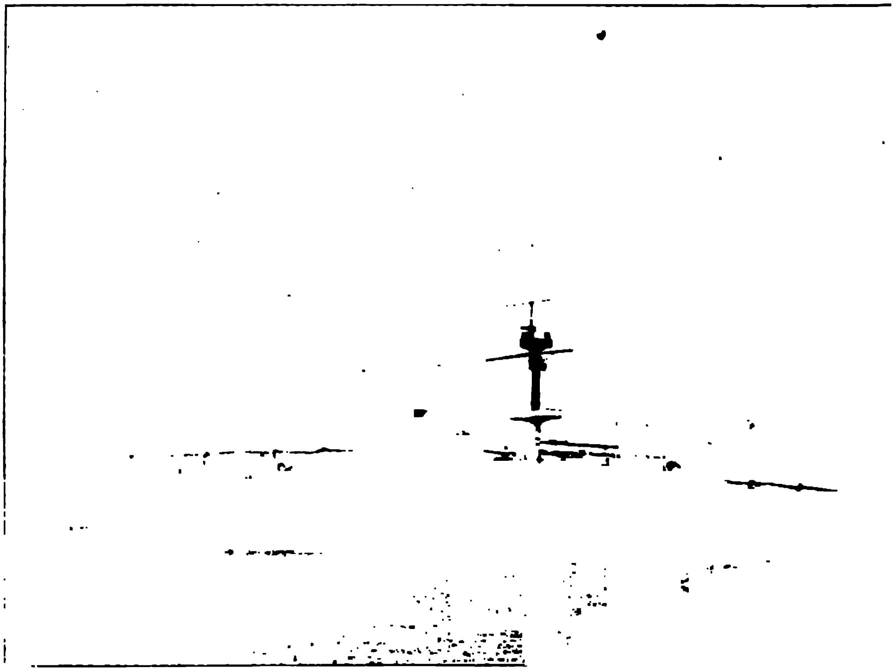
War-Ships and Torpedo Boats.

The Spanish Armored Cruiser *Cristobal Colon*.

The Ansaldo Works, of Genoa, where this superb vessel was built, were founded in 1846, and are considered the most important in Italy. They occupy an area of 220,000 square meters, and use a motive force of 1800 horse-power, and more than 1000 engine tools. The 11,500 workmen, composing the personnel of this establishment are distributed among four principal works:

Sampierdarena, where the engines are made, Sestri-ponente where the hulls are laid, Cornigliano, where the metallargical works are located, and finally, in the port of Genoa, where are the work-shops for the repair and completion of the floating structures.

The *Cristobal Colon* is the second ship constructed in Italy (and at the same works) for a foreign government; the first was the *Garibaldi*, delivered to the Argentine Republic, which differs from the *Cristobal Colon* only in the disposition of the lighter artillery and in the type of boilers used: those of the *Cristobal Colon* are of the Niclausse multitubular system, already in use in the French navy on the *Friant*, the *Elan*, the *Menhir*, etc., while those of the Argentine ship are cylindrical. The plans of the hull of the *Cristobal Colon* are by Commander Masdea, director-general of naval construction at the Italian Navy Department: its characteristic features are as follows:



Length between perpendiculars	100	m.
Beam, maximum	18.50	m.
Draught	7.10	m.
Displacement	7000	tons.

[illegible] by an armored belt of 15 cm., extending along the [illegible] composed of plates of nickel-steel from the works of Terni. [illegible] are lodged the battery, extending over about 2/3 of the length [illegible] armored in front and rear, as well as on the sides, by plates [illegible] varying in thickness from 12 to 15 cm.; the ceiling of the [illegible] composed of steel plates 5 cm. thick, and transverse partitions [illegible] from another. The two barbette turrets which carry [illegible] are protected by steel plates 12 cm. thick, and rest at their lower edge on the ceiling of the battery. Finally, an armored, turtle-back deck, 25 to 30 mm. thick, extends over the entire length of the ship.

The vessel was built in sixteen months.

Armament.—The armament comprises:

1. Two guns of 254 mm. in the two barbette turrets, one forward and one aft; 2. Ten 152 mm. rapid fire guns in the armored battery, five on each board-side; two of them can be used in a chase, and two others in a retreat, 3. Six rapid fire guns of 120 mm., protected by steel shields, placed on the deck; two of these guns can fire in a chase, two others in retiring; 4. The lighter guns scattered over the deck and in the military top; they comprise six 57 mm. and two 37 mm. rapid fire guns, and two machine guns; 5. Five Schwarkoft torpedo tubes, all above water, two on each board-side, one astern.

There are besides, three electric flash-light projectors, two of 40 cm., one of 75.

Engines.—The two engines, absolutely similar to those of the Argentine *Garibaldi* are vertical and triple-expansion. They can each develope 6750 horse-power by forced draught, and give the vessel a speed of 19.6 knots.

The auxiliary engines, with a total of about 500 horse-power, comprise 6 engines for the electric lighting and the working of the turrets, the pumps, ventilators etc.

The normal supply of coal is 600 tons; but rises to 1200 tons if the auxiliary supply be included.

—*Le Yacht*, May 22, 1897.

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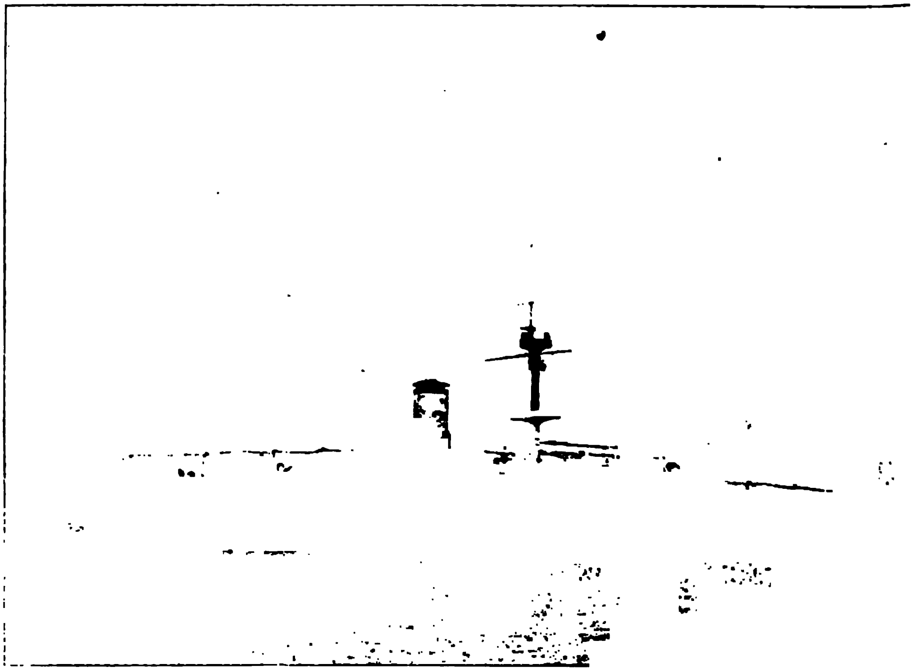

Length between perpendiculars	100	m.
Beam, maximum	18.50	m.
Draught	7.10	m.
Displacement	7000	tons.

Protection is obtained by an armored belt of 15 cm., extending along the entire water-line, composed of plates of nickel steel from the works of Terni; above this belt is arranged the battery, extending over about 2/3 of the length of the ship; it is armored in front and rear, as well as on the sides, by plates also of nickel steel, varying in thickness from 12 to 15 cm.; the ceiling of the battery is composed of steel plates 5 cm. thick, and transverse partitions separate the pieces, one from another. The two barbette turrets which carry the heavier guns are protected by steel plates 12 cm. thick, and rest at their lower edge on the ceiling of the battery. Finally, an armored, turtle-back deck, 25 to 30 mm. thick, extends over the entire length of the ship.

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BOOK REVIEWS.

Die Heere und Flotten der Gegenwart, herausgegeben von C. von Zepelin, K. Preuss. Generalmajor a. D. II. Grossbrittannien und Irland. Berlin: Schall & Grund. 15 Mark. Pp. 537.

This magnificent series appears at a time when all the world seems ready to plunge into war, and navies and armies are the talk of the day. The first volume presents an account of the army and navy of Germany; the present volume is devoted to Great Britain and Ireland.

The portion relating to the army is written by a Lieutenant-Colonel of the British General Staff, and is a most valuable and interesting production. The English army is unique in Europe, as England is practically the only one of the great nations that has been able to retain the system of voluntary enlistment, and has thus far avoided setting up a great standing army, like those of her neighbors on the Continent.

In a brief historical introduction the author traces the principal changes which have taken place from 1660 to the present time, and naturally explains incidentally the origin of the characteristic features of the present organization. The recruiting system, the composition and organization of the various branches of the army, including Militia, Yeomanry and Volunteers, are all described in detail, and with authoritative accuracy. Some of the special features of the organization are the mounted infantry (which England alone endorses), the machine gun sections, and the Army Service Corps. The two last mentioned subjects are especially worthy of study by us, because England has had considerable experience with machine guns in the Soudan, and the army service corps (or something similar) will be a great desideratum in our army in time of war.

The second part relates to the armament of the different branches of the army, and contains a brief résumé of the elementary tactics of the three arms, marches, outposts, systems of supply etc., all of which is set forth clearly and accurately, and with a completeness that is somewhat surprising, considering the small space into which it is condensed. The most noticeable feature to us is the gun pit: our light artillery drill-regulations contain a diagram of an English gun-pit which was new about twenty-five years ago, when Major Sanger brought it to our notice, but which (like all the others in our drill-regulations), have long since become obsolete.

The third part relates to the officers, non-commissioned officers and military schools.

This first portion of the volume, relating to the army, certainly gives a very full and accurate picture of the organization and composition of that body of men that has made its record glorious in all parts of the world, in language that is both entertaining and instructive, always clear and to the point, and without a superfluous word.

The portion relating to the navy is the work of the German Naval Captain A. Stenzel, and opens with a historical review of the growth of the world's greatest sea-power, which forms a most interesting chapter. The organization of the British Admiralty is then treated in detail, followed by an essay on the naval Policy of England and a description of the naval stations, docks etc., at

home and abroad. The personnel of the navy, officers and men, receives careful attention, and the work closes with a masterly description of the material of the navy, ships and guns, that traces its history from the middle of the seventeenth century to the present time.

The illustrations of the book are superb, and many of them are in colors: there are more than a hundred and twenty illustrations in all, and these, of course, add greatly to the value as well as the beauty of the volume. As a work of reference on the subject it is invaluable; there is an air of thoroughness and completeness about it that is very satisfactory to the reader, and the publishers and the authors may well be proud of the result of their labor.

J. P. W.

Aus Meinem Leben. Aufzeichnungen des Prinzen Kraft zu Hohenlohe-Ingelfingen. Vol. I. 1848-1856. Berlin: E. S. Mittler und Sohn. 1897. Pamphlet, 8 Marks; bound, 9.50.

Personal memoirs are always a welcome form of literary production, but particularly is this the case when they emanate from persons who have held high positions and have had experiences beyond the range of ordinary mortals. Prince Kraft zu Hohenlohe-Ingelfingen has done the world a great service in recording the experiences of his eventful life, and presenting them in the work of which the present volume is the introduction. According to the expressed wish of the Prince the publication of these memoirs was not begun until five years after his death, and they are now edited by Lieutenant-General Arved v. Teichman und Logischen.

The Prince's ability placed him at an early age in responsible positions, and led to his rapid advancement and the attainment of high rank; so that professionally his experiences were remarkable and interesting. Moreover, his selection as Adjutant by two monarchs gave him an opportunity of observing at close range the great political movements that swayed the nation. Combined with these exceptional advantages he possessed qualities which rendered the material more than ordinarily available to his land, for he was gifted with high literary attainments, with a keen power of observation and with an excellent judgment, so that he knew how to select his material and also how to present it in attractive and interesting form.

The work is not intended to be history, but personal memoirs in the truest sense, the object being to relate only personal experiences, and to present them with all the feeling and impression made on the author at the time of their occurrence.

The memoirs are preceded by a sketch of the author's life, written by the editor, which places before us the main features of the Prince's life, as well as the strong character of the man, and enables us to more fully grasp the significance of his own words.

The memoirs proper begin with the days preceding the revolution of 1848, when the Prince was already twenty years of age. The account of the feelings prevalent among the peasants in these exciting times is particularly interesting as he had exceptional opportunities for observation, not only officially, but privately, on his father's land, where the latter fed as many as fourteen hundred of his own men at his own cost to keep the deluded men from starving.

Being stationed in Berlin or Potsdam during the revolution he saw the most exciting part of the events there enacted, and gives us a graphic description of his experiences.

The author then takes up the record of the quiet events of ordinary garrison life, begining in 1849, in which many an amusing incident of his superior officers is recorded. In 1850 he entered the war school (*Kriegschule*), and of his life there he gives a most interesting account. In 1853 he returned to his regiment, and we have again some valuable sketches of character and life. His major happened to be Freiherr v. der Goltz, and we have a very delightful little sketch of him as he then was. The following year he was sent to Vienna as attaché, where he remained until 1856, when he was appointed Adjutant his Majesty the King.

During his sojourn in Vienna he carefully studied the Austrian army, and also made a tour through Italy and studied there the armies as well as the historical battle-fields. Gun-cotton and the field telegraph appeared for the first time as factors in the art of war, in Austria at this time, and, of course attracted the Prince's attention.

This first volume, therefore, has much of general interest, but, great as are the events recorded, they are as nothing compared to the events to come, in 1866, and in 1870—1.

The Prince is well known in the military world by his valuable and entertaining *Letters* on Strategy and on the three arms of the service, and military students will be attracted to this new work of his, as much by their interest in the man, as by the intrinsic worth of his work.

The publishers have clothed the work in an appropriate dress, and pape and print are excellent.

J. P. W.

Naval Gunnery. Captain H. Garbett, R. N. The Macmillan Company, 66 5th Ave., New York. Price $1.50.

Great as has been the improvement in all things connected with ordnance and gunnery in the last quarter century there is as yet no appearance of finality. Every new gun, every new carriage and in fact every piece of material shows an improvement of some kind, hence no book on the subject can be quite up to date. On the other hand the field is so vast and broad that it cannot be exhaustively treated within moderate limits—therefore in treating the subject the author must bear in mind the particular object of his work and the particular class of readers which he expects to reach.

In this volume the author has set for himself the task of tracing the history of naval gunnery from the time when guns were first used aboard ships down to the present time; and showing the causes in the development of the modern battleship from the old wooden ship of the line.

The work is intended particularly for non-professional readers and the treatment is such that they will have no difficulty in following the author in his development of the subject.

Particular attention should be called to the chapter on the development of the modern battleship and to that on quick firing guns. In the former is shown clearly the varying position and thickness of the armor and distribution of the armament from the earliest ironclad to the present day. In the latter is treated the marvelous development of the quick firing system and its application to increasing calibers.

The illustrations, paper, and print are all excellent.

C. C. W.

Kriegsgeschichtliche Beispiele aus dem deutsch-französischen Kriege von 1870/71. Kunz, Major a. D. 3. und 4. Heft. E. S. Mittler und Sohn. 4.60 and 1.75 Marks, respectively.

This most excellent series of historical examples from the Franco-Prussian War is continued in two more numbers (3 and 4) concluding the subject of *Night Combats*. We know of no work that is so replete with valuable lessons taught by the great teacher, Experience, than this collection of historical incidents, and none that is so well worthy of careful study by all officers, whatever their rank. On the subject of night combats it stands without a rival, since no other work has ever treated this most important subject in so thorough a manner; but not alone is it valuable in an historical sense, for the separate combats, interesting as they are in their graphic presentation by the author, are made the texts of authoritative discussions on the general subjects involved in night combats, and their proper use in future wars, so that the work as a whole constitutes a text-book on this special, but highly essential and heretofore neglected, branch of tactics.

Number 3 describes 83 night combats, some in the north and north-west of France, others from the campaign on the Loire, and finally a number from General v. Werder's campaign in the south of France. Some idea of the probable importance of night combats in future wars may be derived from the author's statement that nearly all the battles and the more important combats of the war against the French Republic lasted until after dark, and many until far into the night. He found it impossible, therefore, to describe all combats of this character, and included only such as took place in the night, taking into consideration combats which ended in the night only when they presented characteristic features pertaining specially to night combats. This number, although somewhat larger than the preceding ones, loses nothing in interest, indeed, the reader of any one of the incidents described will have to acknowledge on laying aside the work that he has learned something new. The comments, of course, assist the understanding of the events, but also inculcate principles that may stand the student in good stead in the future. Finally, each number closes with a series of problems (110 in this number), which are intended to suggest matter for thought, to illustrate the principles discussed, and to assist the student in the application of these principles to various conditions that may arise in war. Some of these are for the Second Lieutenant, others for the field officer; all are suggestive and instructive.

Number 4 is devoted to night combats in the attack and defense of fortifications, and is, consequently, of special interest to the Artillery officer. The 32 illustrations and examples of night combats, which it describes, are taken from the sieges of Strassburg, Verdun, Belfort and Paris, and furnish rich material for reflection and study.

These two numbers, like the others of the series, are supplied with excellent separate maps and a number of sketches on a larger scale scattered through the text, so that in this respect they leave nothing to be desired.

In conclusion, we heartily recommend this work to military students, and look forward with much interest to the continuation of the series.

J. P. W.

The International Annual of Anthony's Photographic Bulletin and American Process Year Book for 1898. Edited by W. J. Scandlin. New York: E. & H. T. Anthony & Co. Pp. 303. $1.00.

No one could fail to be pleased with the fine appearance of this annual. Its illustrations are excellent examples of the present high standard of American process work and the printer's art; while the contributed articles, many of which are by well known writers and workers in photography and photo-engraving, are upon subjects of interest to all photographic workers.

The many interesting points discussed and difficulties explained in these articles, should render it indispensable to those who are practically interested in these subjects.

The volume is made complete by an appendix containing valuable photographic and process formulae, some of which were, a few years ago, worth hundreds, or possibly thousands of dollars.

J. K. C.

Kriegstechnische Zeitschrift für Offiziere aller Waffen. Ten numbers per year 10 Marks ($2.50). Berlin: E. S. Mittler und Sohn.

This successor of the well-known publication entitled *Archiv für der Artillerie- und Ingenieur-Offiziere des deutschen Reichsheeres*, bids fair to keep up the standard set by its predecessor.

The first number has appeared and its contents speak for themselves:

1. Combustible blank cartridges, for use in small-arms, having the shape of the complete round (including bullet).
2. The modern field gun.
3. Military Ballooning: technical considerations.
4. Russian experiments in crossing streams by means of extemporised material.
5. Telegraphy without wires.

Professional Notes.
Book Reviews.

J. P. W.

Scientific American Supplement Reference Catalogue. New York: Munn & Co., 361 Broadway.

Messrs. Munn & Co. have issued an admirably arranged reference catalogue of the *Scientific American Supplement*, which should be of great use to students of scientific subjects. The importance of the articles may be judged by a few extracts:

Ordnance and armor. (46 principal references).
    Mortars. –Construction of Modern Breech Loading Rifled Mortars.
Torpedoes and Torpedo Warfare. (15 principal references).
    Brennan Torpedo.
    Canet Torpedo Discharge Tube.
    Defense of a Port by Torpedoes.
    Torpedo Warfare.
    Use of Torpedoes in war. E. P. Galway, R. N.

J. P. W.

BOOK NOTICES.

[These books will be fully *reviewed* as space becomes available.]

Der Kampf um Küstenbefestigungen, von Sigmund Mielichhofer, k. u. k. Hauptmann. Wien und Leipzig: Wilhelm Braumüller. 1897. 2 Mark.

Der Griechisch-Türkische Krieg des Jahres 1897. Nach officiellen Quellen von einem höheren Offizier. Berlin: Schall & Grund. 5 Mark.

Kriegsgschichtliche Beispiele aus dem deutsch-franzosischen Kriege von 1870-71. Von Kunz, Major a. D. Berlin: E. S. Mittler und Sohn. 1897.

Fünftes Heft: Attacken. 2 Mark.
Sechstes Heft: Feldartillerie. 1.60 Mark.
Siebentes Heft: Feldartillerie. 1.40 Mark.

Recueil des Travaux Techniques des Officiers du Génie de l'Armée Belge. I. 1897. Ixelles.

Preparatory Battle Formations. Major-General H. Bengough, C. B. London and Aldershot: Gale and Polden. 1 Shilling.

A method of measuring the pressure at any point on a structure, due to wind blowing against that structure. Francis E. Nipher. Transactions Academy of Science of St. Louis.

Artilharia de Campanha. Canhao Krupp de 7.5 *cm., L* 28. C. Leydecker. Rio de Janeiro: *Journal de Commercio.* 1897.

The History of our Navy, from its origin to the present day, 1775-1897. John R. Spears. Four volumes, with more than four hundred illustrations, maps and diagrams. New York: Charles Scribner's Sons. 1897.

INDEX TO CURRENT ARTILLERY LITERATURE.

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Abbreviations employed in index are added here in **brackets.**

All the periodicals are preserved in the Artillery School Library, **Fort Monr**[illegible]
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Aldershot. Copies 6d each.

Arms and Explosives. [*Arms and Ex.*] *Monthly.*
Effingham House, Arundel Street, Strand, London, W. C. Per year 7*s.*

Army and Navy Gazette. [*A. and N. Gaz.*] *Weekly.*
3 *York Street, Covent Garden, London. Per year* £1 12*s* 6*d.*

Canadian Military Gazette. [*Can. Gaz.*] *Fortnightly.*
Box 2179 *Montreal, Canada. Per year* $2.00.

The Engineer. [*Eng.*] *Weekly.*
33 *Norfolk Street, Strand, London. Per year* £2 6*d.*

Engineering. [*Eng'ing.*] *Weekly.*
35-36 *Bedford Street, Strand, London, W. C. Per year* £2 6*d.*

Journal of the Royal United Service Institution. [*Jour. R. U.S.I.*] ***Monthly.***
17 *Great George Street, London, S. W. Per year* 24 *s.*

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Quarterly.
Simla, India. Per year $2.50.

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12 *Hanover Square, London.*

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[*Proceedings I. M. E.*] 19 *Victoria Street, Westminister, London.*

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[*Prof. Papers Corps Royal Eng'rs.*]
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169 *Queen Street, Melbourne, Australia.* ***Per year*** **11 s. 6 d.**

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4-6 *Catherine Street, Strand, London, W. C.* *Per year* £1 10*s* 6*d.*

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13 *Quai Voltaire, Paris.* *Per year* 18 *Fr.*

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PACK SADDLES AND A POWERFUL MOUNTAIN GUN.

With the use of pack animals the variety of packing gear is very great, but the nature of the country to be traversed, of the load to be transported, and in the mountain artillery especially the skill of the soldier as packers, will in a great measure determine the form and adjustment of the gear.

The most important part of the packing gear is the saddle, and in its construction two general methods are followed; one represented by the crude *aparajo*, and the other by the ordinary saddle.

The former are cumbrous, complicated as to gear, heavy in weight, and certain to produce sore backs and disabled mules unless in the hands of skillful packers, even when provided with extra appliances which add to the objectionable weight. The advantages which are claimed for the *aparajo*, are its shape which enables all loads to be balanced, (which has no bearing for mountain artillery material, where all loads balance naturally, as the guns, carriage, wheels, etc., or are carefully constructed to do so, as the ammunition boxes, etc.). It presents much more surface for pressure to the mule, than does any other form of pack saddle. One of our present pack saddles (that for ammunition) very perfectly illustrates the value of this claim. It was constructed under the supervision of one of the oldest and most experienced chief packers connected with the army, and due advantage was taken for the ample "surface for pressure on the mule."

When this saddle was taken into the field during the Pine Ridge campaign, the same chief packer was compelled by that experience to report that * * * "the ammunition pack disabled all the mules that were used with the full load of seventy-two rounds," the reason seemed plain, that the load was carried too low, with three boxes on each side, and brought too great a total pressure on the vital parts of the mule. (Report of Chief of

Ordnance 1892, p. 326). As a matter of fact the muscular construction of the mule or horse ridgidly limits the amount of surface available for the support of a load, and when this is exceeded the saddle is ruined.

The virtues claimed for this form of saddle being summarily disposed of as non-existant so far as applied to the mountain artillery material, there remains only the baggage to be considered, with which, when properly constructed, it may be used to advantage. For this purpose it would be hard to improve on the regular Quartermaster pack saddle, which, with its harness, etc., complete, weighs only forty pounds.

The other general principle upon which pack saddles are constructed and under which nearly if not all foreign pack saddles for the transportation of mountain artillery material are constructed, is that of the ordinary riding saddle, especially as represented by the cavalry saddle in use in any given army.

All cavalry saddles are designed to carry heavy weights, and the nature of these weights is such that it is impossible to distribute it in such a manner as to form a good pack, as respects their front and rear position, though well balanced from side to side. As in nearly all good mountain artillery pack saddles, the construction is based upon that of the cavalry saddle, it will be well to give some consideration to this saddle, its condition and use, and its construction, as the basis of a good pack saddle.

To begin with, the under surface of the saddle—the part coming in contact with the horse's back—we find two principal points of consideration : its shape and its size. As regards shape, the under surface of the saddle should bear as nearly as possible the same relation to that part of the horse's back it is intended to occupy as a mould does to the cast that is taken from it, always excepting the strip lying over the horse's back-bone, which must remain altogether out of contact. As regards the size or extent of the surface of contact, the greater this is with a given weight, the less will be the pressure at any given point, and consequently the less risk of a sore back or other injury to the animal, provided always that the pressure be equally distributed over the whole surface, and the surface be ridgedly confined to that which nature has made suitable to bearing burdens. This latter consideration at once limits the size of the saddle, due to the muscular construction of the animal, and to the further fact that its own weight is a matter for serious consideration ; its weight must be deducted from the load carried, and any increase at once reduces the "useful" load carried.

There are two ways in which the weight of the saddle may be distributed without its useful *under* surface being contracted. The first is to avoid extending the frame or tree, or indeed any part of the saddle, beyond the surface where the pressure ought to be supported, and this being exercised in a perpendicular direction downward, it is not only useless but absurd to make these extend too far *down over the ribs latterly*. The second is to use materials combining great strength and moderate elasticity with the least possible weight.

An inspection of a plate illustrating the muscular development of the animal, will reveal a great, broad, flat muscle along either side of the back-bone, joining the fore and hind quarters, forming the suspension bridge upon which the saddle, which carries the load, must exclusively rest. The size and shape of these great tendons at once determine the size and shape of the side bars of our cavalry saddle. These bars do not extend beyond these muscles and bear upon the ribs extending beyond them.

The side bars should be as wide as possible—the full width of the muscle to its outer limit—and also as long as possible without receiving any of the muscular action of the fore and hind quarters. The angle which they make with each other must be fixed to suit the average animal of the class purchased for the service, when in the average good condition.

The average load carried by our cavalry horse is about two hundred and fifty-five pounds, including the saddle, etc. Now let it be supposed that this weight constitutes a mountain gun to be carried by the horse, the cavalry saddle to be converted into the necessary pack saddle, for its transportation, as is done in European armies. Manifestedly the bearing surface of the saddles must practically remain the same in all respects, though the side bars and their connection should be made stronger and provided with the necessary yokes front and rear, to support the gun. The weight of the pommel, cantel, stirrups, etc., would probably be ample to insure the necessary changes of this character, with from 5.6 to 7.1 pounds of good steel for the construction of good supports for the gun, or carriage, etc., to which must be added the usual pack saddle harness, when we would have the total weight of the resultant pack saddle, without its fitness for proper carrying of the usulal load on the horse's back having been changed in any respect, save that the added crupper render it more secure in its position when the animal travels over a rough and mountainous trail.

Saddle tree (U. S. Cavalry)	weight		17.30 pounds
Extra ironing	"	5.60 to	7.10 pounds
Different cincha and latigo	"		6.00 pounds
Crupper	"		2.75 pounds
Lashing girth and rope	"		3.50 pounds
Corona, canvass lined	"		3.50 pounds
Halter, or hackamore	"		2.60 pounds
Pack saddle, complete	"	45.55 to	47.05 pounds

As a practical fact of no little interest it may here be stated that the old pack saddle for our twelve pounder mountain gun weighed, complete, forty-seven pounds. It was an efficient and suitable pack saddle, and there is no apparent reason why, with modern steel, and methods of construction, that weight cannot be reduced without in any wise impairing the efficiency of the pack saddle.

It is probable that the blanket should be discarded and the under surface of the side bars padded, to be used over a properly made corona, which should be colored red, and marked with the battery designation, etc.

Padded saddles are decidedly objectionable to the professional packer because he has not a harness maker at command. But this objection has little or no force in the mountain battery. If the blanket be retained, then the under side of the side bars should have sheep skin secured to it, to prevent the blanket from slipping.

The Quartermaster pack saddle, provided with proper arches and springs to hold the ammunition boxes and with harness complete, would weigh not more than forty-three pounds. When used for baggage, etc., its weight is forty pounds.

The field artillery should be provided with a mountain gun of the same type as that for horse artillery, and firing the same projectiles. But if the latter gun is of the socalled quick fire pattern, most certainly a mountain gun should not be so. Any modern field gun with a caliber and weight of shrapnel to in any wise entitle it to the name, can, so far as rapidity of fire alone is concerned, fire altogether too rapidly for the limited supply of ammunition which it is possible to take into the field in war, and this restriction is far greater for a mountain gun under the conditions of pack service.

For such a gun, with the maximum weight of shrapnel, "fixed" ammunition is quite out of the question for many cogent reasons not necessary to mention, one alone being sufficient: the weight of brass cartridge cannot be carried by a reasonable number of pack mules.

Assuming that a fifteen pound schrapnel is to be used in the three inch gun under comtemplation, a round would weigh about sixteen pounds, and with a twenty-four pound box, and five pounds for primers, implements, etc., a packed box with six rounds would weigh one hundred and twenty-five pounds. The old U. S. twelve pounder box with the same number of rounds weighed, packed, one hundred and twelve pounds, box twenty.

To fire a fifteen pound projectile with the velocity usual in modern mountain guns, will require a proportional weight of gun and carriage to "stand-up" behind the resultant muzzle energy. In order to secure this necessary weight, it would seem that the best means would be that employed by the English artillery with their so-catled "jointed" gun.

For the ordinary type of mountain gun, not intended to keep pace with cavalry commands on long and rapid marches, a load of three hundred pounds may be considered reasonable, when suitable and first class pack mules are provided.

No provision should be made for wheel transportation which would entail a long and heavy axle which, in the carriage cited below, would have to be unshipped and carried on an extra mule together with the shafts, harness, etc. Of the nearly two hundred mules in a battery at a war strength, not one tenth would derive any benefit from this devise. In the English mountain artillery drill, 1891, p. 89: "Mule Draught (*sic*). It may often be found convenient and more expeditious, in ordinary changes of front in action, and for advancing and retiring short distances, when the ground is suitable, to move by *draught* instead of *limbering up.* The simple method detailed below is devised to meet the above purposes *only, as most mountain artillery authorities are of an opinion that the mountain artillery loose their greatest values as soon as they leave the 'pack system' for that of 'draught'*"—the italics are mine. The draft above mentioned for maneuvring purposes only, is to hitch two mules to the front of a gun carriage by improvised drag ropes and by aid of a special chain; no shaft and harness are found with the battery.

With the pack saddle indicated for a jointed gun we can have:

1st Animal	Pack saddle and harness	50 pounds
	Gun chase	230 pounds
	Equipment, etc.	15 pounds
		295 pounds

2nd Animal	Pack saddle and harness	50 pounds
	Gun breech	230 pounds
	Equipment, etc.	15 pounds
		295 pounds
3rd Animal	Pack saddle and harness	47 pounds
	Carriage body	235 pounds
		282 pounds
4th Animal	Pack saddle and harness	47 pounds
	Two wheels	220 pounds
	Equipment, etc.	15 pounds
		282 pounds
5th Animal	Pack saddle and harness	43 pounds
	Two ammunition boxes, packed	250 pounds
		293 pounds
Baggage Mule	Q.M. Pack saddle and harness	40 pounds
	Baggage	255 pounds
		295 pounds

The load has been taken as 295 pounds to allow five pounds for contingencies of construction, etc. The carriage and wheel packs are, from their nature, both bad packs. The loads for each are thirteen pounds less than for the other packs. and it would be better if the difference were still greater. But the necessity for as much weight as possible is imperative, and relief for the mule when necessary if the work is great, is found in the use of the spare mules which must be provided in every battery.

This would give us as the weight available for standing up behind a fifteen pound projectile when the gun is fired:

Gun	460 pounds
Carriage	235 pounds
Two wheels	220 pounds
Total	915 pounds

The English gun, caliber 2.5, firing a 7.37 projectile with 1440 f.s. and 107 f.t.M.E. weighs without equipments, implements, etc., 924 pounds, or 8.63 pounds weight for each foot ton of muzzle energy. The Hotchkiss 3.00 inch gun weighs 548 pounds, with a 12 pound projectile, 840 f. s., and 59 f. t. M. E., or 9.3 pounds per ton of M. E.

To be on the safe side and certain of not too great recoil, with the latter measure we can have 98 f. t. for a fifteen pound projectile, this gives 970 f. s. Greater than this velocity we do not desire for a mountain gun, as at about this velocity the law of atmospheric resistance changes from the third to the fifth power, and any material increase in the muzzle velocity, while greatly increasing the muzzle energy and consequent recoil, would not materially increase the remaining velocity at battle ranges.

Such a gun would be greatly superior to the English gun, and in fact would have no superior among mountain guns; at the same time if we adhere to the fixed axle, we would have one mule less for the transportation of the gun, carriage, etc., than is required for the English gun.

Ninety-six rounds can be carried on eight mules, which is entirely satisfactory as compared with foreign batteries, and especially so when the weight of the shrapnel is considered.

There can be no question as to the stability of the carriage, as there is ample weight to insure a strong axle, when it is of minimum length. As the gun is heavier than the carriage its inertia will conserve the latter.

The muzzle section of the gun should not exceed 45 inches and the breech section about 26 inches in length.

The ordinary screw joint of the English gun has proved serviceable and satisfactory, though a better one might possibly be found in the use of some form of breech mechanism, as the slotted screw, with a slight conical taper to insure easy withdrawal.

With smokeless powder in cartridges, protected from moisture in some simple manner, it is quite evident that with a slight modification of the Quartermaster pack saddle, a fifteen pound projectile is entirely practicable in so far as regards a proper pack load. But it is also evident that it is impossible to secure a sufficient velocity for such a weight of projectile, without doubling the weight of the ordinary mountain gun, as has been done in the English service with such satisfactory results. Each section of the gun as above weighs 230 pounds, the French 3.15 inch gun weighs 231. The sections of the English gun weigh 200 pounds each, but this weight increased by 30 pounds would make very little difference to the cannoneers in the handling of the gun in sections, or as a whole.

A gun such as has been indicated would be much more powerful and efficient than was our old three inch M.L. Rifle in its day, which is saying not a little.

Even hampered to some extent by the use of their jointed gun, the English mountain batteries in India have always been the peers of any in "smartness" and efficiency, though it must be conferred that the weight of the material is excessive, requiring a complete set of "relief" mules for its gun and carriage, etc., with 179 men, 100 native muleteers (hired), eight horses, and one hundred and ninety-six (196) mules.

If we should have to go to Cuba, mountain batteries would be necessary almost if not quite exclusively, and no mountain gun has been produced which could in any wise compare with that here indicated, even though the system fall very far short of what has been indicated above.

A. D. Schenck,
Captain, Second Artillery.

NOTE TO PLATE II.

In all figures the abscissas denote the distances from the target, or from the mean points of impact, to the gun. The ordinates give the probability that the target stands at the distance corresponding thereto, if the shots fired at the several distances denoted by — or + (in front or in rear of the target) were observed as these attached signs indicate.

The probability that the target stands between any two distances will be expressed by the ratio of the area included by the corresponding ordinates and the curve, and the entire area bounded by the curve. (Compare in Fig. 1 the shaded portion.)

The numbers written in the diagrams give the probability expressed in per cent.

BY ROHNE, LIEUTENANT-GENERAL AND GOVERNOR OF THORN.

The author of the present study addresses not so much the company officers, as those officers, who by their positions at the Shooting School, the Artillery School, or the Artillery Proving Commission, are detailed to work at the practical and theoretical development of the art of shooting. In this, the present work, we are to submit to proof the reliability of the trial shots, and to investigate whether the observance of the target practice book offers a sufficient guarantee that we are to receive with quick certainty an ample effect; or whether we are able to alter the operations of shooting to secure this object. Deep mathematical knowledge is not essential to this undertaking; a certain intimacy with logarithmic calculation, and a knowledge of the most elementary principles of probabilities, are sufficient.*

As is well known, all rules for shooting prescribe that the target shall first be brought into a fork by two shots— a short and an over shot—this fork by being divided gradually contracts, and so the distance of the target will be approximately ascertained. If there were no "*scattering*" (Streuung) we should be able by continual bisection of the fork to carry out our range-finding very quickly to any desired degree of accuracy. The 'scattering' is but one cause of wrong fork constructions; that is to say, the target itself may not be between the two limiting distances; although determined by one shot in front and one in rear, it may nevertheless be found outside these distances. If, for example, a shot fired with the elevation for 2000 m. is in front of the target, and one with the elevation for 2100 m. is in rear of it, the target may still be nearer than 2000 m. or farther away than 2100 m., because the shot with an elevation for 2000 m. may be accidentally a short shot, or that with an elevation for 2100 m. accidentally an over shot. Only by the delivery of a number of shots with the same elevation, can we aquire accurately the true location of the target.

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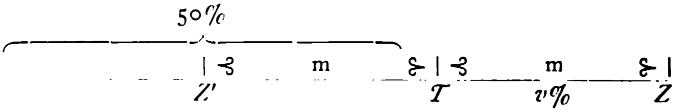
* The suggestion of the following work, I owe to the very concise exposition (A'propos du jeu de tir), which is published by Captain Magnon in the *Revue de L'Armée Belge* (18 6, July-August). This work supplementing mine in the second part of the "Artillery Fire Game." applies to the consideration of the reliability of fork building, and verifies my deductions in a satisfactory manner—that which is entirely new and interesting in this work, is its strict scientific examination of the question; with what certainty can we draw our conclusions as to the definite position of the target, from the observation of any shot? The method is here repeated.

It is evident that the number of short and over shots bears an entirely definite ratio to the extent of the "*spread*" (Streuung) and the location of the mean point of impact with reference to the target; which ratio may be determined by means of the Theory of Probabilities. If the firing, for example, is at 2000 m. with an elevation proven to be correct for the conditions, one half of all the shots should fall in front, the other half in rear of the line across the range at 2000 m. If the firing, on the other hand, is somewhat too short, that is to say, if the mean point of impact falls in front of this line, we shall receive more shots in front and fewer in rear of the line.



If the mean point of impact, *T*, falls at the distance *m* in front of the target *Z*, it is easy to calculate the number of projectiles which will found in the enclosed space *TZ*. The space *ZZ'*, twice *TZ*, = 2 m. If *s* is the mean "*spread*," (Streuung) $\frac{2\,m}{s}$ is the probability factor, and it enables us to read off at once from the known table of probability factors the number denoting the % of "hits" which fall in this space. Then in the space *TZ* falls half of these hits. If the % of hits which fall in the space *TZ* is represented by the number *v*, of every 100 shots we shall have 50 + *v* short shots; because half of all shots lie on this side of the mean point of impact *T*.

Example.—How many short shots do we get at 2000 m. when the mean point of impact lies 20 m. in front of the target?

1. Under the supposition of a mean spread as set down in the range table (i. e. mean spread of 23 m)., and

2. Under the supposition of a mean spread of 50 m.

In this case *m* is equal to 20, *s* equals 23 (or 50). The probability facter will therefore be $\frac{40}{23} = 1.74$ or $\frac{40}{50} = 0.80$). This factor corresponds, according to the table, to 76 % (or 41 %) of hits. We get, consequently, 50 + 38 = 88 % (or 50 + 20.5 = 70.5 %) of short shots.

We thus have for every position of the mean point of impact with reference to the target, expressed by the relation to the mean spread, an entirely definite per cent of short or over shots.

amount of the mean spread is not known in the shoot- It depends upon many contingencies, new ones arising ry shot; and it changes continually, even during the course firing. As is well known, the deductions of the range table ade under favorable circumstances; they apply also only to articular gun. In the firing by the battery, under service tions, the numbers of the range table should, at least, be ed, so that the proper fighting ranges of about 3500 m. could imated to within about 50 m. In cases of great accuracy, our investigation, the range table will not answer at all. following compilation (Table I) shows, for the various ons of the mean point of impact with reference to the , the percent of all shots fired, which we may probably t to find as short or as over shots; or, what is the same it shows the probability of getting a short or an over shot. reasons which will appear later the logarithm of this ratio is placed opposite its number.

TABLE I.

1	2	3	4	5	6
Position of the mean point of impact with reference to the target.		Probability, p, of a short shot.	log p*	Probability q, of an over shot.	log q*
Mean spread (s)	m				
— 3	— 150	1.0	10.0	0	
— 2.75	— 137.5	0.9999	9.999	0.0001	6.000
— 2.5	— 125	0.9996	9.999	0.0004	6.602
— 2.25	— 112.5	0.9988	9.999	0.0012	7.079
— 2.0	— 100	0.9965	9.998	0.0035	7.544
— 1.75	— 87.5	0.9909	9.996	0.0091	7.959
— 1.5	— 75	0.9785	9.990	0.0215	8.332
— 1.25	— 62.5	0.954	9.979	0.046	8.663
— 1.0	— 50	0.911	9.959	0.089	8.949
— 0.75	— 37,5	0.844	9.926	0.156	9.193
— 0.5	-- 25	0.750	9.875	0.250	9.398
— 0.25	— 12.5	0.632	9.801	0.368	9.566
∓ 0	∓ 0	0.50	9.699	0.50	9.699
+ 0.25	+ 12.5	0.368	9.566	0.632	9.801
+ 0.5	+ 25	0.250	9.398	0.750	9.875
+ 0.75	+ 37.5	0.156	9.193	0.844	9.926
+ 1.0	+ 50	0.089	8.949	0.911	9.959
+ 1.25	+ 62.5	0.046	8.663	0.954	9.979
+ 1.5	+ 75	0.0215	8.332	0.9785	9.990
+ 1.75	+ 87.5	0.0091	7.959	0.9909	9.996
+ 2.0	+ 100	0.0035	7.544	0.9965	9.998
+ 2.25	+ 112.5	0.0012	7.079	0.9988	9.999
+ 2.5	+ 125	0.0004	6.602	0.9996	9.999
+ 2.75	+ 137.5	0.0001	6.000	0.9999	9.999
+ 3.0	+ 150	0.0000	—	1.000	10.000

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omplete the logarithm, subtract 10.

This table is also to be used for every other amount of mean spread; column two being made to correspond to the change. If, for example, the mean spread is not 50 but only 25 m., all the numbers in column two would become one half of what is here set down; on the other hand, they would be doubled if the mean spread were 100 m.

To illustrate—if the mean point of impact lies 25 m. in front of the target, we shall have, according to the table, 750 of every 1000 shots in front, and 250 in rear of the target. We should get this same ratio by perfectly accurate observation of the shots. Experience teaches, however, that not every shot will be correctly observed; a part will be incorrectly observed, and many more will be of questionable accuracy. In my book appearing in 1881—"The Firing of Field Artillery"—I stated that according to the list prepared by me at the Artillery Shooting School, 62 shots of every 100 used in the construction of the fork will be correctly, and 7 incorrectly observed, while 31 will be of questionable correctness. Since the questionable shots probable detract from the success of the trial shots, at least sufficing to make the work uncertain, they must be entirely left out of consideration; there remains then 1 incorrect to 9 correctly observed shots. [62 to 7.] This ratio was, during the time of black powders, subject to only small fluctuation; how it varies when using the smokeless powders, I have not been able to ascertain. On the one side, the observation is made easier by reason of the falling away of the smoke; but on the other, it has become more difficult, on account of being less easily distinguished from objects in the landscape.

Our extended investigation will be on the ground of the ratio of 1 shot incorrectly, to 9 shots correctly observed. Then each one can easily form for himself an idea as to how the results will be changed, due to more favorable or to less favorable observation. We make also the additional supposition, not exactly corresponding to the actual circumstances, that the trustworthiness of the observation shall be independent of the distance of the point of impact from the target. It appears that the observation of shots falling close in front or in rear of the target (always remembering that the wind may carry the smoke of a projectile falling close in front of the target, to the rear of the target, and vice versa) will be more difficult and less reliable than that of shots which fall at some considerable distance in front or in rear of the target. It is entirely possible that in the observation of those shots falling very near the target, we may get one incorrect to five correct observations; while of the shots falling, say, 200 m. in front or in rear of the target, we may have, perhaps 20 correct to 1 incorrect observation. This possible error in our supposition does not have a large influence upon our results.

If, therefore, among 10 shots observed, we have, on an average, 9 correct and 1 incorrect observation, so we shall have to continue our example, only 675 of the 750 short shots (i. e. $\frac{9}{10}$ of 750) observed in front of the target, the other 75 being observed in rear of the target. In the same way, of the 250 over shots, 225 will be observed in rear and 25 in front of the target. The number of shots which will be observed in front of the target, will therefore be, under this supposition, $675 + 25 = 700$; similarly for the number of shots observed in rear of the target, we have $225 + 75 = 300$. If the mean point of impact lies 25 m. in front of the target, we have consequently, the probability of the observation of one shot in front of the target equal to 7/10; that of the observation of one shot in rear is 3/10.

To make the problem general: let p (Table 1) be the number which represents the probability of *receiving* a short shot for any position of the mean point of impact with reference to the target, and q the same for an over shot: therefore $p + q = 1$. The probability P of *observing* one shot in front of the target would, by absolutely certain observation, naturally, be equal to p; and the probability Q of *observing* one shot in rear of the target, would be equal to q. But if among 10 observations only 9 are correct and 1 is incorrect, it follows from the preceeding, that the probability P of observing a short shot is $.9 \times p + .1 \times q$; and the probability Q of observing an over shot is $.9 \times q + .1 \times p$.

Now $.9p + .1q = \frac{9p + q}{10} = \frac{8p + 1}{10}$ (since $p + q = 1$).

In the same way $.9q + .1q = \frac{8q + 1}{10}$.

The probability P of observing a short shot is therefore $\frac{8p + 1}{10}$.

The probability Q of observing an over shot is $\frac{8q + 1}{10}$.

Example.—The mean point of impact lies 12.5 m. in front of the target; according to Table I, $p = .632$ and $q = .368$. The probability P of the observation of one shot in front of the target is consequently $\frac{8 \times .631 + 1}{10} = 6056$. The probability Q of the observation of one shot in rear is $\frac{8 \times .368 + 1}{10} = .3944$.

By means of this calculation the probability of the construction of a correct fork with reference to any target of which the range is known, can be readily ascertained. Suppose the range of a target is 2350 m., the fork is correctly constructed if the shots fired for the purpose are observed as follow:

2200 —
2400 +
2300 —

According to Table I, the probability p of receiving a shot in front of this target when firing at the elevation for 2200 m. is equal to 1 (since $2350 - 2200 = 150$). The probability q of receiving a shot in rear when firing with the elevation for 2400 m. is 0.911. And in like manner, the probability p of receiving a shot in front of the target, when firing with the elevation for 2300 m., is 0.911.

Accordingly, the probability that the shot fired at 2200 m. will be observed in front of the target is $\frac{8 \times 1 + 1}{10} = 0.9$; the probability that the shot fired at 2400 m. will be observed in rear of the target is $\frac{8 \times .991 + 1}{10} = 0.8288$; which is also the probability that the shot fired at 2300 m. will be observed in front of the target.

In order that the 200 m. fork shall be correctly constructed it is necessary that the shot fired at 2200 m., as well as that fired at 2400 m. be correctly observed. The probability of the occurence of the two events is, according to the principles of probabilities, equal to the product of the probabilities for the occurence of each event separately, therefore it is $0.9 \times 0.8288 = 0.7452$. In the same way the probability that the 100 m. fork shall be correctly constructed is $0.9 \times 0.8288 \times 0.8288 = 0.6176$. If all of the observations were always correct, the probability of correct construction of the 200 m. fork would be $1 \times 0.911 = 0.911$; that of the correct construction of the 100 m. fork would be $0.911 \times 0.911 = 0.8299$.

If the target distance were 2325 m. instead of 2350 m., the probability of a correct conrtruction of the 200 m. fork would, by uncertain observation, be increased to 0.795; on the other hand, that for the 100 m. fork would be decreased to 0.556. By absolutely certain observation the probabilities of correct construction of these forks would be 0.977 and 0.713, respectively.

So we see, the success of the correct construction of a fork depends not only upon the trustworthiness of the observations, but also, in great measure, upon the accidental situation of the targets. The nearer the middle of the fork lies to the target, so much greater is the prospect that the fork will be correctly constructed. The shooting, however, is not so much for the purpose of finding the probability of the correct construction of a fork for a definite position of the target, as for finding out with what degree of certainty a conclusion as to the distance of the target can be drawn from the observations of the shots fired.

By the method employed for the ranges of 2350 and 2325 m., let us calculate the probability figures for an entire series of distances (for example, 2050, 2075, 2100, 2125, etc., to 2650 m.) by using the shots, which, fired with elevations corresponding to the respective ranges, were observed as follows: 2200 —, 2400 +, and 2300 —. We may now construct a curve, laying off to scale, upon a right line taken as the axis of abscissas, the ranges 2050, 2075, 2100, etc., to 2650 m., and as ordinates the probabilities calculated for these ranges; in our case, for example, for 2325 m. the ordinate would be 0.556, for 2350 m. 0.618, etc. The ordinates for the three shots given—2200, 2300 and 2400—would be those resulting from observation. The length of the ordinate terminated by the curve (see Plate II, fig. 2) will give the probability that the observation turns out as supposed for each distance of the target. Now it is clear that the probability (in reality the probability that the observations of the three shots result as here given) is proportional to the probability that the target itself is to be found at the corresponding distance. In our example the probability that the range is 2350 m. is to the probability that the range is 2325 m. as 0.618 is to 0.556 or as 1.11 is to 1; that is to say, if the observations of the shots fired with the elevations for 2200, 2400, and 2300 m. result as here given, then it is more probable that the target stands at 2350 m. than at 2325 m.

The probability that the target lies between two limiting distances, for example, between 2300 and 2400 m., (that is, the probability that the fork of 100 m. is correctly constructed) is equal to unity (a certainty), since the surface contained between the respective ordinates (cross-hatched in fig. 2) is equal to that enclosed by the entire curve (integral). If the calculations were gone through with in the manner heretofore given for the distances 2350 and 2325 m., there would be no end to the work; at all events, the work thus applied would be entirely out of proportion to the results obtained.

This calculation admits of being very much simplified. To this end we make use of the following table, which gives the probabilities P and Q that a shot will be observed in front or in rear of the target, under the supposition that the mean point of impact has a determinate position with reference to the target, that the mean spread amounts to 50 m., and that, of every ten shots, nine will be correctly and one incorrectly observed.

TABLE II.

1	2	3	4	5	6
Position of the mean point of impact with reference to the target.		Probability P of observing a short shot.	log P	Probability Q of observing an over shot.	log Q
Mean spread (s)	m				
— 3.00	— 150	0.9000	9.954	0.1000	9.000
— 2.75	— 137.5	0.8999	9.954	0.1001	9.000
— 2.50	— 125	0.8997	9.954	0.1003	9.001
— 2.25	— 102.5	0.8990	9.954	0.1010	9.004
— 2.00	— 100	0.8972	9.953	0.1028	9.012
— 1.75	— 87.5	0.8927	9.951	0.1073	9.031
— 1.50	— 75	0.8828	9.946	0.1172	9.069
— 1.25	— 62.5	0.8633	9.936	0.1367	9.136
— 1.00	— 50	0.8291	9.919	0.1709	9.233
— 0.75	— 37.5	0.7754	9.890	0.2246	9.351
— 0.50	— 25	0.70	9.845	0.30	9.477
— 0.25	— 12.5	0.6057	9.782	0.3943	9.596
∓ 0.0	∓ 0	0.50	9.699	0.50	9.699
+ 0.25	+ 12.5	0.3943	9.596	0.6057	9.782
+ 0.50	+ 25	0.30	9.477	0.70	9.845
+ 0.75	+ 37.5	0.2246	9.351	0.7754	9.890
+ 1.0	+ 50	0.1709	9.233	0.8291	9.919
+ 1.25	+ 62.5	0.1367	9.136	0.8633	9.936
+ 1.50	+ 75	0.1172	9.069	0.8828	9.946
+ 1.75	+ 87.5	0.1073	9.031	0.8927	9.951
+ 2.0	+ 100	0.1028	9.012	0.8972	9.953
+ 2.25	+ 112.5	0.1010	9.004	0.8990	9.954
+ 2.50	+ 125	0.1003	9.001	0.8997	9.954
+ 2.75	+ 137.5	0.1001	9.000	0.8999	9.954
+ 3.00	+ 150	0.1000	9.000	0.9000	9.954

This last condition distinguishes Table II from Table I, since in the latter all observations were set down as correct. Colums 3 and 5 in Table II are calculated from the formula $P = \frac{8p+1}{10}$ and $Q = \frac{8q+1}{10}$, in which p and q are taken from Table I. The use of Table II as here given would very much shorten the necessary calculations, since the logarithms of the probabilities to be multiplied need only be copied and added. However we may provide a device to still further lessen the labor of the calculations. For this purpose cut from a piece of card paper a strip, and divide it into equal spaces from one to two cm. wide. In these spaces write the numbers of column 4 of the table (the logarithm of the probability of the observation of a short shot) from right to left. Thus we have a "Strip for Short Shots," to which we prefix the minus sign. For our purpose it is sufficiently accurate if we carry out the logaritmhs to two places of decimals and also take as our intervals of distance 25 m. instead of 12.5 m. Where greater accuracy is required the logarithms may be carried out to three places of decimals and the intermediate distances may also be recorded. The column which corresponds to the probability of the observation of a short shot, when the mean point of impact falls at the target (where the number 9.70 stands) is indicated by the mark (Ab).

The "Strip for Over Shots" is constructed by writing the numbers in column 6 in the same manner, prefixing thereto the plus sign. To illustrate these strips:

For short shots:

							Ab					
—	9.00	9.00	9.01	9.07	9.23	9.48	9.70	9.85	9.92	9.95	9.95	9.95

For over shots:

							Ab					
+	9.95	9.95	9.95	9.95	9.92	9.85	9.70	9.48	9.23	90.7	9.01	9.00

These strips would really be of infinite length; but the probability of the observation of a short shot, according to the supposition made, is at the most, 0.9 (log of 0.9 = 9.95), when all the shots lie in front of the target, and at the least, only 0.1 (log of 0.1 = 9.00), when all of the shots lie in rear of the target. Therefore the "Strips" will all begin and end with the repetition of the numbers 9.00 or 9.95. Now draw a straight line and divide it into parts which correspond to the width of the spaces on the strip; number these parts to correspond to the ranges which can come into consideration, for example, 2000, 2025, 2050, etc., to 2600.

In order to ascertain, by the method under discussion, the probability of the observation in front of the target, of a shot fired with the elevation for 2200 m., place the strip for short shots with the mark (Ab) on the number 2200, then under the number 2150, for example, stands 9.23, which means that the probability, that a shot fired with the elevation for 2200 m. will be observed in front of the target, is the number whose logarithm is 9.23 (= 0.17), if the target stands at a distance of 2150 m. In the same way, it is found that the probability is the number whose logarithm is 9.95 (= 0.9), if the target distance is 2275 m. or more, etc.

TABLE III.

	2000	2025	2050	2075	2100	2125	2150	2175	2200	2225	2250	2275	2300	2325	2350	2375	2400	2425	2450	2475	2500	2525	2550	2575	2600
	9.00	9.00	9.00	9.00	9.01	9.07	9.23	9.48	ↄb 9.70	9.85	9.92	9.95	9.95	9.95	9.95	9.95	9.95	9.95	9.95	9.95	9.95	9.95	9.95	9.95	9.95
	9.95	9.95	9.95	9.95	9.95	9.95	9.95	9.95	9.95	9.95	9.95	9.95	9.95	9.95	9.92	9.85	ↄb 9.70	9.48	9.23	9.07	9.01	9.00	9.00	9.00	9.00
Sums	8.95	8.95	8.95	8.95	8.96	9.02	9.18	9.43	9.65	9.80	9.87	9.90	9.90	9.90	9.87	9.80	9.65	9.43	9.18	9.02	8.96	8.95	8.95	8.95	8.95
Number corresponding to the log.	0.09	0.09	0.09	0.09	0.09	0.10	0.15	0.27	0.45	0.63	0.74	0.79	0.79	0.79	0.74	0.63	0.45	0.27	0.15	0.10	0.09	0.09	0.09	0.09	0.09

If we now lay one of the strips for over shots with the mark (ↄb) under the range number 2400, and then add the logarithm standing in the perpendicular column, the sum so obtained is th logarithm of the probability that th shot fired with the elevation for 2200 m will be observed in front of the target and that, fired with the elevation fo 2400 will be observed in rear of the target. The number corresponding to this logarithm is the required probability.* Table III will make the method plain. The taking out of the logarithms will be greatly facilitated by the use of Table IV. This is the reverse of the ordinary logarithm table, where the logarithm of every one of the series of natural numbers is given; in Table IV, the number corresponding to every logarithm from 1 too 100 is given. This table can of course of extended indefinitely and the logarithms carried out to a greater number of decimal places.

With the numbers of Table III (last line) we may now construct a curve in the manner described on page 143, of which the ordinate will correspond to the probability that a shot fired with the elevation for 2000 m. will be observed in front, and one with the elevation for 2400 m. in rear of the target, when the distance of the target corresponds to the abscissa (Plate II, fig. 1).

We see from the data of Table III, as well as from the figure, that the probability that the two shots fired with elevation for 2200 and 2400 m. will be observed as stated (one in rear and one in front of the target) is greatest when the distance to the target is 2300 m.; it

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[*] Remembering that the probability of the occurence of two separate independent events is equal to the product of the probabilities that each of these events will occur.

is there, for example, about eight times as great as when the distance to the target is 2125 or 2475 m. We conclude from this, inversely, that if these shots are observed as above mentioned, the probability that the distance to the target is 2300 m. is greater than the probability for any other distance; and that it is about eight times more probable that the target distance is 2300 m, than that it is 2125 m. (or 2475 m.)

TABLE IV.

Log.	Num.	Log.	Num.	Log.	Num.	Log.	Num.	Log.	Num.
01	10	21	16	41	26	61	41	81	65
02	10	22	17	42	26	62	42	82	66
03	11	23	17	43	27	63	43	83	68
04	11	24	17	44	28	64	44	84	69
05	11	25	18	45	28	65	45	85	71
06	11	26	18	46	29	66	46	86	72
07	12	27	19	47	30	67	47	87	74
08	12	28	19	48	30	68	48	88	76
09	12	29	19	49	31	69	49	89	78
10	13	30	20	50	32	70	50	90	79
11	13	31	20	51	32	71	51	91	81
12	13	32	21	52	33	72	52	92	83
13	14	33	21	53	34	73	54	93	85
14	14	34	22	54	35	74	55	94	87
15	14	35	22	55	35	75	56	95	89
16	14	36	23	56	36	76	58	96	91
17	15	37	23	57	37	77	59	97	93
18	15	38	24	58	38	78	60	98	95
19	15	39	25	59	39	79	62	99	98
20	16	40	25	60	40	80	63	100	100

The probability that the fork of 200 m. is correctly constructed, or that the target stands within the limiting distances—2200 and 2400 m.—remains equal to unity (1), since the area of the cross-hatched surface is equal to the entire surface bounded by the curve (Plate II, fig. 1). The probability is, as already mentioned, theoretically infinitely great, on occount of the supposition that of all shots fired $\frac{9}{10}$ will be correctly and $\frac{1}{10}$ incorrectly observed; therefore the two branches of the curve will run parallel to the axis of abscissas. However, it appears that the probability of the incorrect observation of a shot falling 200 m. in front or rear of the target is very small, and indeed a shot falling 200 m. in front or in rear of the target will be observed with a much greater degree of certainty than that indicated by the ratio of one incorrect observation in every ten. We will therefore consider the observation of all shots falling more than 300 m. from the target as absolutely reliable; that is to say, we will take into consideration only about 300 m. (to scale) of the curve on each side of its highest point, which point corresponds to the most probable target distance. This will approximately correct the error of our supposition, that all shots will be correctly observed. In our example also, the probability that the target stands between 2200 and 2400 m. (that the 200 m. fork is correctly constructed) is equal to 1, as in fig. 1. the area of the cross-hatched surface is equal to that lying between the ordinates for 2000 and 2600 m.

It is easily understood that the areas are always proportional to the equidistant ordinates (the sums that are given in the bottom line of Table III), by which we notice that the shaded surface has for its limit the ordinates for 2200 and 2400 m.; therefore the ordinate for 2000 and 2600 m. should be accepted as only half as great. These sums are for the shaded surface 5.56, and for the entire surface 7.86.

Let *w* denote the desired probability for the correct construction of the fork; then we have $w:1::5.56:7.86$; hence $w = \frac{5.56}{7.86} = .707$; in other words, under the supposition made (mean spread 50 m., $\frac{1}{10}$ of all shots incorrectly and $\frac{9}{10}$ correctly observed), of every hundred forks of 200 m., the **probability is** that 70.7 will be correctly **and 29.3 incorrectly** constructed. **For the construction of the fork of 100 m. a shot must be fired with the elevation for** 2300 m., and the **observation taken.** To ascertain the probability **for a correctly constructed fork a strip for short** shots with the mark (ᕲ) **at 2300 m. will** be placed under the line of **Table III** giving the sums of the **logarithms; the** sums of the logarithms in the **table and** on the strip will be taken **and the corresponding** numbers set **down (see** Table V).

TABLE V.

	2000	2025	2050	2075	2100	2125	2150	2175	2200	2225	2250	2275	2300	2325	2350	2375	2400	2425	2450	2475	2500	2525	2550	2575	2600
From Table III	8.95	8.95	9.95	8.95	8.96	9.02	9.18	9.43	9.65	9.80	9.87	9.90	9.90	9.90	9.87	9.80	9.65	9.43	9.18	9.02	8.96	8.95	8.95	8.95	8.95
	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9 01	9.07	9.23	9.48	ᕲ 9.70	9.85	9.92	9.95	9.95	9.95	9.95	9.95	9.95	9.95	9.95	9.95	9.95
Sums	7.95	7.95	7.95	7.95	7.96	8.02	8.18	8.43	8.66	8.87	9.10	9.38	9.60	9.75	9.79	9.75	9.06	9.38	9.13	8.97	8.91	8.90	8.90	8.90	8.90
Number	0.009	0.009	0.009	0.009	0.009	0.010	0.015	0.027	0.046	0.074	0.130	0.240	0.400	0.560	0.620	0.560	0.400	0.240	0.130	0.093	0.081	0.079	0.079	0.079	0.079

The bottom line of this table shows that the greatest probable target distance is not more than 2350 m. We calculate from this the area of the surface bounded by the curve from 2050 to 2650 m. (the value of the ordinates for distances over 2600 m. remains at 0.079). The probability that the target lies between 2300 and 2400 m. (that the 100 m. fork is correctly constructed) is found by the foregoing practical method to be $\frac{2140}{4083} = 0.524$; that is, for every 100 forks of 100 m., there will probably be 52.4 correctly, and 47.6 incorrectly constructed.

Let us extend our investigation to a fork of 50 m. For this purpose a shot is fired at 2350 m. If this gives a + observation (over shot) the probability that the target stands between 2300 and 2350 m. is 0.387. If it gives, on the otherhand, a minus observation (short shot) the probability of the correct construction of the fork of 50 m. (target between 2350 and 2400 m.) is reduced to 0.314 or in other words, nearly $\frac{2}{3}$ of all forks of 50 m. will be incorrectly constructed (see fig. 3 and 4 of the Plate).*

We have previously investigated two cases, namely:

Case I.	Case II.
2200 —	2200 —
2400 +	2400 +
2300 —	2300 —
2350 +	2350 —

In case I, the observations of the four shots furnish a very good guarantee that the target stands between 2200 and 2400 m., the probability of this amounting to 0.707, after the delivery of the first two shots; it is increased, after the observation of the last two shots, to 0.878 (see fig. 3).

In the second case, on the other hand, the probability for the correctness of the 200 m. fork is diminished by the observation of the last two shots to 0 503; that is, in this case the probability that the target lies at a greater distance than 2400 m. is proportionally greater (see fig. 4).

For this reason the Austrian Firing Regulations contain the provision that when only one of the shots fired for the construction and narrowing of the fork is observed in front of the target, and all the others in rear of it (or vice versa), the shot in question shall be repeated in order to "control" the fork.

We will now investigate the correctness of the fork construction when one cause of incorrect forks, namely, incorrect observation is entirely elininated, and the "scattering" is the only remaining source of error. The method of the examination is exactly the same as before, except that we turn to Table I instead of Table III for the application of our "strips."

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* These calculations as well as all that follow have been worked out with three place logarithms, and range intervals of 12.5 m. instead of 25 m.

We find then, that the probability for the correct formation of the 200 m. fork increases from 0.707 to 0.851, and that of the 100 m. fork, from 0.524 to 0.707 (see fig. 5 and 6). If the shot fired at 2350 m. falls in rear of the target (case I), the probability that the 50 m. fork is correctly constructed is 0.509 (against formerly 0.387); if, on the contrary, it falls in front of the target (case II), the probability of the correct construction of the fork is 0.485 (against formerly 0.314). In each case the increase in the probability of the correct construction of the 50 m. fork due to correct observation is very small.

The most of my honored readers will be astonished at the large number of incorrectly constructed forks, and will perhaps think that these results are in contradiction to those of actual experience.* But the opposite is the case, as I have shown conclusively in the work intitled "Correctness of Fork Construction." I have frequently brought to my notice, during the revision of Shooting Lists, or in discussions, the entirely erroneous view that the fork will be correctly constructed if all the shots fired for the purpose are correctly observed. It is evident that by such a definition we shall receive a greater number of "correctly constructed" forks. But the correctness of the fork construction is as much influenced by a shot having a large deviation from the mean trajectory, as by an incorrect observation. If, in spite of correct observation, a fork be incorrectly constructed on account of the deviation of one of the individual shots which, under certain circumstances, may be but a very small deviation, the battery commander naturally discovers no fault. But the mere fact that the fork is incorrect (e. g. if for a target of 2199 or 2401 meters, a fork of 2200/2400 is constructed) will make no difference. Incidentally notice, that the fork may be correctly constructed by means of incorrect observation; if, for example, a shot which must cause an incorrect construction of the fork in consequence of its deviation, be accidentally incorrectly observed. We may also have a case of correct fork construction if the probable target distance is so near one of the two fork limits that, by a continuation of the shots upon this limit, we find we have determined the range (that is, the least practicable correction—25 m.—would not improve the situation of the mean trajectory, and would perhaps

* I will later compare the results of calculation and experience.

make it worse). According to this definition, there would be among a 100 forks of 200 m. 78.3 instead of 70.7 correctly constructed; and of the forks of 100 m., 65.3 instead of 52.4.

Now, every incorrect construction of the fork is not equivalent to a failure of the shooting; the correct construction of the fork only insures a greater success. According to the Firing Regulations for the Field Artillery, a fork of 100 m. will be constructed by firing with shrapnel, alternating with time fuse shrapnel, and fired at the two fork limits. The Target Practice Book regards the bursting point as unfavorable, if among six shots more than one falls in rear of the target; in other words, if the mean "bursting distance" comes under 20 m.; on the other hand, we read (Par. 41) that mean bursting distances of from 30 to 130 m. give good results. Proceeding on the supposition that mean bursting distances from 20 to 130 m. will probably give good results, we can by time fuse shrapnel firing, alternately upon both limits of the 100 m. fork, expect to get good results at least at one of the limits, and from one-half of all the shots fired, if the target stands no more than about 30 m. nearer than the short fork limit, or about 80 m. farther than the long fork limit, supposing that the fuses burn correctly. If the fork is constructed between 2300 and 2400 m., we may therefore count upon good results if the target stands between 2270 and 2480 m. The probability that this is the case, taking from Table V, is $\frac{3242}{4083} = 0.794$; that is, in 20.6 % of all cases we cannot expect to receive effective results from the alternate firing at the two limits of the 100 m. fork.

According to par. 94 of the Target Practice Book, if it is plain that the range is short, the firing in these circumstances should alternate upon the long fork limit and a distance 100 m. greater.

In our example we may therefore, as will appear later, be permitted to count upon effective results if the target stands at a range not greater than 2580 m. The probability that the target stands between 2270 and 2580 m., is calculated to be 0.87, i. e., in 13 % of all cases there will be no sufficient effect obtained. It is most likely then, if we get no apparent results, that the target stands nearer than 2270 m., when in changing the time fuse shrapnel firing to the short fork limit, according to our rule, the remainder of the percussion fuse shots are observed in rear of the target, in which case we should proceed to the construction of a new fork.

It must here be remarked, that these deductions only hold for the case where the bisecting shot of the 200 m. fork (shot at 2300 m.) is observed in front of the target. If it be observed in rea of the target, so that the fork must be constructed between 220 and 2300 m., this in no way alters the probability that the fork will be correctly constructed. Consequently, the probability o receiving effective results by the time fuse shrapnel fire, at both fork limits, remains approximately unchanged.* On the othe hand, we can in this case rarely expect effective results more than about 100 m. beyond the long fork limit, then the probability that the target stands between 2170 and 2480 m, is 0.81, while the probability that the target stands between 2170 and 2380 m., is 0.79. It will often happen when changing the time fuse shrapnel firing, under the rule, to the short fork limit, that the already loaded percussion fuse shots will be observed in rear of the target, and this necessitates the construction of a new fork, with a short limit 100 m. smaller than before.

In the same way that we calculate the probability of the correct construction of a fork, we may determine the probable position of the target by means of several shots fired with the same elevation (group shooting). The method of investigation is exactly that heretofore described. According to the Target Practice Book (par. 80) one can safely consider the battery as shooting at the proper range, if $\frac{1}{3}$ to $\frac{2}{3}$ of the observed shots lie in front of the target. If necessary, corrections shall be made, according to the rule, after six observed shots are fired. One is also shooting at the proper range if he has observed :

1. 3 shots — and 3 +
2. 4 " — " 2 +
3. 2 " — " 4 +
4. 2 " — " 2 +

The fourth case fulfils the requirements, although only four shots have been observed, because the proviso of the Target Practice Book (par 80) is independent of the observation of the fifth and sixth shots, without which $\frac{1}{3}$ to $\frac{2}{3}$ of the shots would still be observed in front of the target.

The most probable position of the mean point of impact, is, in the first and fourth cases, at the foot of the target; in the second case about sixteen meters in front; and in the third sixteen meters in rear of the target; and this depends, not at all upon the reliability of the observation, but solely upon the amount of scattering or spread. If this, for example, be doubled, the mean point of impact in the second and third cases will lie twice as far from the target; if it be halved, the mean point of impact comes correspondingly nearer to the target.

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* It falls from 0.794 to 0.788, which is practically the same thing.

What interests us here most of all, is the degree of certainty with which we may settle upon a definite position of the mean points of impact with reference to the target, basing our conclusions upon the observations of our "Range Shooting." The next thing is to establish what is to be understood by correct "Range Shooting." I understand it to mean, such a position of the mean point of impact with reference to the target, that the least practicable correction (for the Field Gun, 25 m.) will not improve the position of the sheaf, but the reverse. We have correct range shooting at 2300 m., for example, if the target stands between 2287.5 and 2312.5 m. The probability for this is 0.271 in the first case (3 shots — 3 shots +) (fig. 8); in the fourth case (2 —, and 2 +) it is 0.171 (fig. 9); if the limits between which the target is allowed to stand be extended, for example, from 2257 to 2325 m., these probabilities increase to 0.481 and 0.314 respectively. From this we see that the probability of having excact range shooting is by no means very great, although in both these cases the probability that the target is at a distance of 2300 m. is greater than that for any other distance (compare fig. 8 and 9). In the second and third cases the probability that the target stands between 2287.5 and 2312.5 m. is 0.237. The most probable target distance is in these two cases 2284 and 2316 m. respectively* (fig. 10).

If we suppose in advance that only correct observations are to be considered, this naturally increases very materially the reliability of the range shots in the first and fourth cases, for example, in the first case (3 shots —, 3 shots +) the probability of exact range shooting (target between 2287.5 and 2312.5) increases to 0.476 (instead of 0.271); the probability that the target stands between 2275 and 2325 m. would increase to 9.793 (instead of 9.481). Under the supposition of a mean spread of only 25 m. (measured by the range table 23 m.) the probability, by the observation of three shots in front and three shots in rear of the target, of exactly correct range shooting would be 0.793. In the fourth case (2 —, 2 +) the probability of exactly correct range shooting increases to 0.395, instead of 0.171. In the second and third cases (4 —, 2 + and 2 —, 4 + respectively) the probability of correct range shooting increases to 0.316, instead of 0.120. (Fig. 11 to 13).

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* It may be remarked that the probability of correct range shooting comes out very often considerably greater if we also consider, as we properly should, the shots fired for the construction of the fork. Since it is not here a question of absolute, but rather of relative accuracy, we can in the interest of simplicity, omit this refinement.

From the foregoing investigation, it is to be seen that the certainty of correct fork construction is by no means very great. For this reason there are in the firing regulations of all countries, certain rules intended to prevent the failure of the trial shots. For instance, in Germany, as is well known, it is prescribed tha time fuse fire with shrapnel shall be used alternately upon th two fork limits, and under certain circumstances shall also b used at a distance 100 m. greater than the long fork limit. I this last case the method is very slow, even on the proving ground; in the presence of the enemy, perhaps too slow. Moreover the regulation, prescribing that a new fork shall be built, if, by changing to the time fuse fire, the already loaded percussion fuse shots are collectively observed in rear of the target, increases the certainty of the results.

The Russian (and older Austrian and the French) firing regulations prescribe for the control of the fork, a second shot to be fired at each fork limit. If the observation of the second shot turns out the same as the first, the respective fork limits may safely be regarded as correctly ascertained; if the observations are contradictory, two other trial shots must be fired. If the observation of these two shots agrees with that of the first two shots above, they are taken as correct, as are also the respective fork limits thus determined. If, on the contrary, the observation agrees with the second pair of shots above, the first pair of shots, and therefore the respective fork limits, must be regarded as incorrect. Finally, these two shots may be differently observed, but of the four shots, two may lie in front and two in rear of the target, in which event the respective fork limits are regarded as target distances, and we change at once to time fuse fire.

We will now investigate reliability of forks of 200 and 100 m. when thus controlled.

If the fork be constructed at 2200/2400 m., and two shots at 2200 m. are observed in front of the target, and two at 2400 m., in rear of the target, the probability that the target stands between 2200 and 2400 m. is 0.895, while the probability of the correctness of the uncontrolled fork is only 0.707. By means of the control, the number of incorrectly constructed forks will be reduced from 29.3 % to 10.5 %, a reduction of almost of one-third. If the firing be alternately with the time fuse shrapnel at 2020, 2300 and 2400 m., we may count upon receiving, in 97 % of all cases, favorable mean bursting distances (from 20 to 130 m.)

at one of the three ranges; while, by an uncontrolled fork of 200 m., we may rely upon effective results in only 86.5 % of all cases; that is, in only 86.5 % of all cases may we expect the target to stand between 2170 and 2480 m. (compare fig. 14 with fig. 1).

If the wide fork were constructed between 2200 and 2400 m., and the fork of 100 m. between 2300 and 2400 m., and if the control of this fork gives two shots in front of the target at 2300 m., and two in rear at 2400 m., the probability that this fork is correctly constructed will be 0.763, against 0.524 for the uncontrolled fork, the number of incorrect forks is also reduced from about 48 to 24 %—a reduction of one-half. The probability of getting the target within the mean bursting distance—20 to 130 m.—at one of the ranges, when firing with time fuse shrapnel alternately at 2300 and 2500 m. is 0.886, against 0.79 by the uncontrolled forks. The number of failing shots is reduced by the control from 21 to 11 %—a reduction of about one-half (fig. 15).

The prospect of obtaining a correct fork of 100 m., is naturally smaller than that for a correct fork of 200.; therefore, the effect of the alternate fire upon the limits of the 100 m. fork is about half greater than it is when the space between the limits of the 200 m. fork is taken under fire. The ratio is here entirely similar to that of all business enterprises; a high degree of certainty is always combined with relatively small profits, and high profits are always attended by a greater risk.

The control does not always turn out so favorably as here assumed. We have yet to examine how large the probability of correct fork construction is, if at one limit the first two shots are manifestly incorrectly observed, and only the following shall contribute to the correctness of the fork. Suppose, for example, that at 2400 m. two shots are +, at 2200 m. 1 + and 3 —, by our observation. In this case the most probable target distance will not be, as in the cases taken heretofore, 2300 m. or perhaps arger, the calculation gives about 2235 m. The probability that the target stands between 2200 and 2400 m. is 0.875 (fig. 14 a), only about 0.02 less than if at the outset by the control, two shots at 2200 m. had been observed in front of target. In the same way, the probability of obtaining mean bursting distances from 20 to 130 m. by the time fuse fire at 2200, 2300 and 2400 m. successively is somewhat smaller (0.95 against 0.97). The probability of the correct construction of the fork is always considerably higher by the controlled, than by the uncontrolled method. It is easily seen that the calculation for the 100 m. fork will turn out entirely similar, so that the deduction of these results will not be required.

The probability that, if four shots, fired at the same elevation, are observed two in front, and two in rear of the target, this distance can be regarded as proven to be correct, has already been given above (page 153). The probability that with the time fuse shrapnel fire at this distance, we shall get the target within the mean bursting width of from 20 to 130 m. is calculated to be 0.487 (fig. 9). That is not very high, but we must notice that, if the other fork limit is controlled, this is somewhat increased (to about 0.54). If the firing is all at one range, the effect is naturally twice as great, or three times as great, as if the firing were alternately at two or three ranges; since in these cases one-third or two-third of all the shots must have unfavorable bursting widths.

Let us investigate one more particular case. In the second edition of my "Artillery Fire Game" I made the proposition to control the 200 m. fork, and afterwards to open with a time fuse shrapnel fire at the distance bisecting this fork.* If the already loaded percussion fuse shots are observed to fall half in front and half in rear of the target, we should not disperse the shot, but continue the time fuse shrapnel fire with this distance. Therefore, the control of the limits of the wide fork increases very considerably the probability that the target distance agrees with the distance which bisects the wide fork. For example, if at 2200 m. two shots are observed in front, at 2400 m. two in rear of the target; at 2300 m. two in front, and two in rear of the target, the probability that the target stands between 2270 and 2280 m., or, what is the same thing, the probability that by time fuse shrapnel fire at 2300 m., with correctly burning fuses we get the target within the mean bursting width of 20 to 130 m., is 0.78, that is, almost exactly the same as the probability (0.79) of getting a favorable mean bursting width at one of the fork limits, after building a 100 m. fork by time fuse shrapnel fire alternately at the two fork limits. The effect is exactly twice as great when firing at a single distance. This favorable result will be attained by the delivery of one more percussion fuse shot (fig. 16).

The new French "Manuel de tir" gives another method of controling the fork, the "verification de la hausse." Suppose the fork of 2200/2400 m. to be constructed; now fire a shot at the bisecting distance of the fork—2300 m. If this be observed in front of the target, the long fork limit (2400 m.) will be controlled; if in rear, the short fork limit (2200 m.) will be controlled. The control will be carried out according to the above given rule. We may have

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* The proposition was to control the 200 m. fork and to change to the time fuse shrapnel fire at the distance which bisects the fork. If the observations show a majority of shots in front of the target the bisecting distance should be taken instead of the greater fork distance; if more shots in rear of the target, the short fork distance should take the place of the greater one; if, on the contrary, the shots are seen to fall equally in front and rear of the target, the bisecting distance should be retained as the true range.

(a)	(b)
2200 −	2200 −
2400 +	2400 +
2300 −	2300 +
2400 +	2200 −

If the control turns out favorably, of four shots in each case, two will be observed in front, and two in rear of the target.

The probability that by this control the 200 m. fork is correctly constructed is then found to be 0.881, that for the correctness of the 100 m. fork being 0.651. By firing alternately at the two fork limits we obtain in example (a) (2300 short fork) favorable mean bursting widths in 85.6 % of all cases, and in example (b) (2200 m. short fork) in 91 % of all cases (fig. 17). The control seems, in this manner, to give a high degree of certainty as well for the correctness of the fork, as for the result of the time fuse shrapnel fire. The number of incorrectly constructed 100 m. forks is decreased from 48 to 35 %. The number of failing shrapnel shots (by which one receives favorable mean bursting widths at neither of the two fork limits) is reduced from 21 % (100 − 79 = 21) to the mean value of 12 % (100 − 88 = 12). Under the supposition that all observations are correct, the probability of a correct construction of the 100 m. fork is increased by this control from 0.707 to 0.759.

From these deductions it is apparent that the control—of both fork limits or of only one—increases the degree of certainty of the range finding shots considerably.* The loss of time caused by firing one shot (for more is not necessary) cannot possibly come into consideration, for, everything depends upon the accuracy of the trial shots. On this account, there is, in the firing regulations of all countries, a rule, which recommends or prescribes such control. The regulations of France and Russia have already been mentioned. The Italian firing regulations prescribe the trial of the fork—especially at great distance—as soon as a doubt exists as to its correctness, in order to make the faults of observation and measurement of the least possible harm. The Swiss firing regulations order the proving of a doubtful[*] shot, by firing a second one at the same range. The Austrian regulations prescribe that, if, in the construction of the short fork (100 paces) one shot is observed in front, while all the other shots fired in the construction of the fork, are observed in rear of the target (or vice versa), the one shot in question shall be repeated. They go, therefore, not quite so far as the French regulations. In the cases explained on page 157, the Austrian regulations would not emyloy any control, but, suppose the data were about as follows :

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* I will not deny that circumstances can arise under which the control by repetition of a shot promises no benefit. Let us consider, for example, that about 300 m. in front of a target at a range of 2500 m., a single small bush is found standing as a mask; in this case shots fired with elevations of 2300 or 2400 m., and striking behind the mask, but in front of the target, will very likely be incorrectly observed, as experience teaches. Such cases, no matter how seldom they arise, detract from the probability of control. In all other cases I consider the control very useful, no matter whether one supposes correct or unfavorable observations.

(a) 2000 — or (b) 2400 +
2400 + 2000 —
2200 — 2200 +
2300 — 2300 +

In example (a) a second shot would be fired at 2400 m., and in example (b) at 2000 m. The German firing regulations prescribe that, after the formation of the 100 m. fork, time fuse shrapnel firing is done first at the short, and then at the long fork limit, alternately. If the fork is formed by the observation of three shots, (at 2200 —, 2400 +, 2300 +) the most probable target distance is, of course 2250 m., and therefore the alternating fire at 2200 and 2300 m. is entirely correct. If the observation of the loaded percussion fuse shots, after changing to the time fuse shrapnel firing results in more shots in rear than in front of the target, the most probable target distance is not more than 2250 m., but may be even smaller than 2200 m. Assuming that the fuses burn correctly, the most probable bursting width is about 50 m. (at 2200 m.) and therefore, in the above case, the bursting points undoubtedly lie about 100 m. in rear of the target. In this case it would be better to go back about 100 m. (the guns are already loaded, fuses cut) ; for, there is no reason to give more confidence to the first shot fired at 2200 m., than to the following percussion fuse, provided that they are well directed and intelligently observed, which is not always the case.

Suppose, that, after the command for time fuse shrapnel firing, one observes two shots in rear and one in front of the target (including also the shots fired in construction of the fork, two in front and two in rear of the target) then the fork distance becomes at once the most probable target distance. According to the probability curve, by alternate time fuse shrapnel firing at the two fork limits, one can count upon a mean bursting distance of 20 to 130 m. in 62 % of all cases; on the other hand, by alternating the fire between the short fork distance and a distance 100 m. smaller, we may count upon 77 % of all cases, that is, about one-fourth more (fig. 18). The operation, according to the firing regulations, would give a still more unfavorable result, if, of the remaining (loaded) shots, one is observed in front, and three or even four in rear of the target.

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[*] "Doubtful" does not mean the same as "questionable." The regulation does not prescribe which is meant It appears at all events to mean a shot, whose observation in the series gives occasion for reconsideration.

The firing regulations are, in may opinion, too rigid and binding—too hard and fast, on this point being in strict contradiction to the spirit of all other rules, which permit some latitude to suit the circumstances of the case. What is prescribed in the firing regulations might, under certain circumstances, be the worst possible thing that could be done.

For the continuation of firing with percussion fuse after the construction of the fork, it is possible to make a few abbreviations which can be of some consequence in the firing of torpedo time fuse shells. According to paragraph 79 of the firing regulations, after the formation of the 50 m. fork, the firing shall be continued at the short fork distance.*

According to paragraph 82 of the firing regulation, a "correction of 50 m. shall be made, if the first three shots at the same range show equal deviations. Should this correction of 50 m. prove to be too much, a second correction of 25 m. in the opposite direction will be made." This will generally be so understood that (most likely) six shots must be fired at the range in question before it can be taken to be correct. If, for example, three shots are observed in front of the target at 2300 m., and three in rear at 2350 m., the probability that 2325 will prove to be the correct range (that is, that the target stands between 2312.5 and 2337.5 m.) is 0.345; in other words, it is larger, than if we had observed three shots in front, and three shots in rear of a target standing at 2325 m., which latter probability is only 0.27 (see page 153). This is an interesting and surprising result and is principally useful in shortening the trial shooting.

The occasion now offers to investigate the value of the probability that the target stands in the middle of the narrow (50 m.)

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* It may be incidentally remarked, that the distance which bisects a fork, has the greatest probability, as may be seen from all our calculations and curves. There is then no reason for the continuation of the firing at the short fork distance. It would be better to continue firing, either at the fork limits alternately, or at the distance bisecting the fork. If the fork is constructed at 2200 2300 m., the narrow fork is determined by a shot at 2350 m. There is in my opinion no ground for going back to 2300 m., if a shot at 2350 m. is observed in rear of the target. That is useless waste of time. So long as one used powder shells, and expected good results from them, he had a good right to continue the firing at the short limit of the fork, then only shots in front of the target gave prospect of effective work. This is already changed by using torpedo shells against plainly visiable objects, and more so still against covered objects, when firing with percussion fuse, serve only to ascertain the range. Here it is solely a question of the shortest way to get at the target.

fork, if, at each limiting distance, only two shots are observed in front of the target and two in rear. This probability is 0.25, that is, it is a little less than if firing with the same elevation at one range, three shots are observed in front, and three in rear of the target; and, on the other hand, it is greater than if two shots were observed in front, and two in rear of the target; and twice as great as if four shots were observed in front, and two in rear of the target (or vice versa). What follows from these deductions? That by the observation of four shots in front, and two in rear of the target (or vice versa), one can consider himself to have found the range; consequently, the control of the 50 m. fork is sufficient evidence of a satisfactory determination of the range; then it affords the same, if not a greater, degree of certainty, for the correct investigation of the range, as if one had observed at one distance one-third to two-thirds of the shots in front of the target*.

The accurate shooting for the range with percussion fuse make a change in the operations absolutely necessary. We have firing lists which show that one battery commander fired forty-eight (!) shots—in which questionable observations are doubtless included—before he considered himself to have found the range to within 25 m. It has been known to happen that sixty-five shots, i. e. 43 % (!) of the entire supply of the battery have been used for this purpose. This investigation retains its importance, even if the field guns of the future carry no torpedo shells, for the conditions are very little different when using howitzers.

What I desire to accomplish in my present work, is to prove that the operation of finding the range can be made more reliable, and at the same time shortened, and to show how this may be done. The more unreliable the observation, and the greater the scattering, the more uncertain will be the shooting for the range, and, therefore, the more necessary to control.

In peace manœuvres such errors as these do not perhaps make themselves of so much importance as would appear from the foregoing, and it may be for this reason, that the observations appear somewhat more reliable, and the scattering somewhat less than I have assumed. In serious work (war), toward which all peace maneuvres are directed, even the most excellent personnel (or staff) must doubtless assume the contrary, and thence becomes absolutely necessary a greater degree of certainty of the range finding shots, although taken between wider limits, but in that case no great accuracy can be expected.

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* If we exclude entirely all incorrect observations, not all that we have said above will apply, but it in no way changes the result. Under this supposition, for instance the probability that one would be shooting at the correct range, if the middle of the 50 m. were taken as the distance would be [illegible], when at each fork limit three shots had been observed in front or in rear of the target respectively; and it would be 0.355, if only two shots had been correspondingly observed. If one has observed three shots in front, and three in rear of the target, when firing at a single distance, the probability of obtaining, at this distance, correct range shooting is [illegible]; with two shots in front, and two in rear, the probability is [illegible]. The probability that the distance, which bisects the fork, will prove to be the range, if at both fork limits two shots in front and two in rear are observed $\left(2300\,{}^{-}_{-},\ 2350\,{}^{+}_{+}\right)$ is indeed smaller than that given by the observation of four shots, fired with the same elevation of which two were observed in front and two in rear of the target (2325 —, +, —, +). But it is larger at least than if one firing at a single range, had observed four shots in rear and two in front of the target (or vice versa), this probability being only 0.316 (page 153).

That my suppositions are not so far from the truth, and especially, that my methods of calculation are reliable, may be seen from the following. In the second edition of my "Artillery Fire Game," I had published some results of the target practice of a battery (pp. 79 and 86). Two hundred and thirty-one firing records were examined—a collective body of shots, by which the range could be accurately established by the observations on the target. The fork of 220 m. was correctly constructed one hundred and fifty-eight times (68.4 % of all cases), and incorrectly constructed seventy-three times (31.6 % of all cases); the foregoing investigation (under the supposition that one-tenth of all the observations are incorrect, and that the mean length of scattering is 50 m.) gives 70.7 and 29.3 % respectively. The fork of 100 m. was constructed correctly one hundred and thirty-eight times (59.7 % of all cases) and incorrectly ninety-three times (40.3 % of all cases);our calculations giving 52.3 and 47.7 %, respectively. The shots at the two limits of the 100 m. fork, assuming correctly burning fuses, gave a prospect of favorable mean bursting distances one hundred and seventy-seven times (in 76.6 % all cases), the calculation gives 79.4 %. This agreement between theory and practice is well worth considering.

I would be pleased, if these deductions should give occasion to one person or another, for a wider investigation of the subject, even though a different result be obtained. The object is not that the foregoing deductions should come to be known as correct, but that the truth should be sought out, which generally first occurs through the refutation of error. However, I must earnestly protest against any man's laying aside these deductions at the outset, with the remark: "This is all only Theory, in Practice everything will be different." To these gentlemen I would be compelled to answer: "You call that 'Practice' which you cannot prove, and that 'Theory' which you cannot refute."

CONCLUSION.

The foregoing work was ready for the press, when a friend called my attention to the fact that the Government Secretary, Dr. Pochhammer, Professor of Mathematics in the Kiel University, had also been engaged some time before, in an investigation of the reliability of the fork construction. This problem is still in the air, so to speak. Upon applying directly to the well known gentleman, he has been good enough to furnish me with the most reliable information. His investigation, with the help of the higher mathematics employed, extended solely to the construction of a fork by means of two shots—one short and one over—and all observations were assumed to be correct. The problem was in this way very much simplefied. Professor Pochhammer in his calculations arrived at the conclusion, that the probability P of correctly constructing a fork in this manner may be expressed by the formula

$$P = 1 - 0.59 \cdot \frac{s}{r}.$$

In this formula "s" denotes the mean spread, and "γ" denotes the width of the fork. Under the supposition made by me, that $s = 50$ m. we get by this formula

$$P_{\gamma=200\text{m.}} = 1 - 0.59 \cdot \frac{50}{200} = 1 - 0.1475 = 0.8525$$

$$P_{\gamma=100\text{m.}} = 1 - 0.59 \frac{50}{100} = 2 - 0.295 = 0.705$$

$$P_{\gamma=50\text{m.}} = 1 - 0.59 = 0.41.$$

According to my calculation under the supposition of only correct observation (p. 150), we get

$P_{\gamma=200\text{m.}} = 0.851$
$P_{\gamma=100\text{m.}} = 0.707$
$P_{\gamma=50\text{m.}} = 0.509$ or 0.485, giving a mean of 0.497.

The agreement of the values for the forks of 200 and 100 m. is very close, and therefore will be an argument for the reliability of my adaptation of Capt. Magnon's method.

For the fork of 50 m., the difference is somewhat considerable; the reason for this lies, however, not in the incorrectness of my adapted method, but in the fact, that, as Dr. Pochhammer has had the kindness to inform me, the formula deduced by him is valid only for wide forks, and an alteration is necessary to make it applicable to narrow forks. Dr. Porhhammer excludes from his investigations all forks of which the probability for their correctness falls under two-thirds; and this therefore allows the formula to be simplified.

That the formula does not hold for short forks can be immediately seen if we make $\gamma = 25$ m., in which case the formula gives

$$
\begin{aligned}
P_{\gamma = 25\,\text{m.}} &= 1 - \frac{50}{25} \cdot 0.59 \\
&= 1 - 1.18 \\
&= \quad - 0.18,
\end{aligned}
$$

which is manifestly impossible, since a negative probability is plainly imaginary. Incidentally note, that the foregoing adaptaion of Magnon's method gives a probability of 0.271 that a fork of 25 m., constructed by the observation of two shots, is correct.

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[Translated by Lieutenant *J. A. Shipton*, 1st Artillery.]

SHRAPNEL FIRE FROM FIELD HOWITZERS AND MORTARS.

Discussion by MARTIN PREHN, Captain in Department of Fireworks. Former
Superintendent of Proving Ground of Friedrich Krupp, Meppen.

Archiv für die Artillerie und Ingenieur-Offiziere, February, 1896.

The discussion of the effects of shrapnel fire from field howitzers and mortars is unavoidable, since there are, at the present time, so many opinions adverse to this kind of artillery. There is no better way of reaching living objects standing behind cover but, at the same time, there is no shot harder to put into the right place.

This firing, scarcely controllable when using a single gun o the target range, escapes almost entirely from the control of the battery commander, not only in pitched battles, where there are naturally so many sources of error, but also in the more careful firing of sieges.

The idea which is superficially formed, by all but the advanced artillery officer, of the effects of shrapnel fire from field howitzers and mortars is erroneous, and, for that reason, this kind of fire is often wrongly estimated. With many it is compared to a rain, falling vertically, covering and beating down everything beneath it.

The question to be discussed is simply: what initial velocity is most suitable for shrapnel with the present system of field howitzers and mortars?

We are not considering a new system of guns and projectiles, but the best use to be made of the existing material by the simplest service, conditioned on the easiest and most reliable system of practicable observation.

High angle fire guns, called howitzers and mortars, on account of their mounting and their short bore, permit an elevation of at least 45°, therefore, on account of this property, it is often concluded that their province is to always fire in the greatest curved trajectory.

For this reason their position is often selected in such a manner as to take away from their facility for observation, which is the most essential condition for effective firing, since what the battery commander does not see he will not believe.

This advantage is lost, of course, when the opposing guns are put up in covered positions, but in placing our own guns under cover the great advantage of being able to change the target at will is given up. In sieges the most dangerous enemy is not always the one we fire upon in previously determined directions. In the defense account is taken of this by arranging revolving turrets and the like.

The short bore of the high angle guns allows only a small chamber, and this permits the use of smaller charges, than the so called service charges, and also a variation in the initial velocity; the short chamber always gives sufficiently high gas pressures, and secures as far as is possible equal velocities.

It is otherwise in the longer cannon; the long chamber, which is fitted for a large charge, causes the small charges to fly apart and to burn irregularly from shot to shot.

The power of elevation allowed by construction therefore, no longer indicates the only difference between cannon and howitzers and mortars, as now all siege guns have a high power of elevation; this difference rather lies solely in the possibility of a variation in the charge. This change in the charge is required at various distances, depending on cover of the enemy and consequent smallest angle of fall.

Effective covering demands as the smallest angle of fall an angle of at least 25°; the tangent of 25° is 0.47; therefore with a parapet 0.47 m. high the closest hit will strike the ground one meter behind the interior crest. As the cover for a man would not be under 4 × 0.47 m. or 1.88 m., the closest hit in that case would fall at a distance of four meters from the interior crest, and as the trail of an enemy's cannon reaches to about 4 meters behind the parapet, so this angle of fall of 25° for a shrapnel will be considered sufficient to strike all stationary or moving objects behind the guns; besides, it is to be observed that a few shots which strike the parapet near the interior crest often pass through and become effective as battery hits. In the field there is usually no reason for so strong a protection for the artillery, a gun so protected is harmless, since it cannot be fired even although the cannoneers serve it kneeling. It must not be forgotten that every man believes himself covered if he cannot see the enemy from his position. How otherwise were the service of a gun possible?

The following illustration shows the efficiency of such a high covering: On the practice ground of a large force of artillery, firing under war conditions, a redoubt was to be fired on at a range of 2000 meters, which covered a portion of its men to over

45°. In firing 72 shrapnel from a battery of 12 cm. howitzers, there were found on the board targets representing these, naturally, very few hits, but in the remaining protected space there were about 55% of the targets, representing standing men, struck. The battery commander fired for the first time with these mortars, and the fire was, consequently, rather rapid fire than observation fire. The effect on the parapet with the small charge was, of course, unsatisfactory.

It is easy to obtain from the range table a charge which will give an angle of fall of 25° or greater, so that it should be easy in this firing with howitzers or mortars to solve every problem, which the covering of the enemy gives, by using the proper charge and elevation. It is fortunate for the defenders that this is not the case, however.

There are many circumstances which render it difficult to effectively strike narrow targets. There are mortars the accuracy of which with shell, at least on the target range, causes astonishment ; it is much easier to reach a hostile position behind cover by means of shrapnel and destroy the enemy, since the under side of the sheaf increases the angle of fall. The angle of fall may either be increased or diminished from the fact that the axis of the projectile is not always tangent to the trajectory but may make an angle with it in any direction. This deflection increases with the elevation and when reducing the initial velocity. The shrapnel always throws its bullets in the direction of its axis, so that the balls take a direction which cannot be fixed beforehand, consequently the shot may be useless; this is generally the case in firing at an elevation of 60° from which especially good results are expected when firing with curved trajectories. In shooting shrapnel from the 21 cm. howitzer, each containing 1700 balls, a total of 17000 balls, at a range of 2000 meters, at 60° elevation, the record of each shot was taken down, but, perhaps because the bursting point was unfavorable to the covering, the result was absolutely nothing. Notwithstanding more extended searches, not one of the 17000 balls was found within a radius of more than 100 meters. The bullets had gone neither too far nor had fallen short, they had simply disappeared.

Reliable observers stood near the targets and distinctly saw the course of the empty shells after the burst. This would always be possible since the path of the empty shells is independent of the path of the full shot, indeed in searching near the empty cases no balls were found. The fire of shrapnel under 60° is therefore to be avoided, aside from the fact that i ncombat one will be in condition to follow changes in elevation exactly rresponding to cutting of the fuze.

It happens at times that the charge of balls is scattered to the ht and left, and, although the most favorable bursting points e selected the whole charge of balls falls on one side or the her of the target.

This is of great importance in shooting at field batteries, where e guns are 15 meters apart. Seen from the side the cannoneers e all apparently destroyed, but upon searching all the balls are und lying between the pieces; yet the battery commander has en all the shots explode at the proper point, and can only assure mself by personal inspection that he has missed. A peculiar enomenon may be mentioned here which may influence the ection of the balls. In firing with low velocities, or with low vations, it is noticed how the shrapnel at the moment of burst- g suddenly stops, and sometimes even makes a distinct back- rd movement; there can in this case be no control of the attering of the balls.

In both cases the velocity of the projectile is destroyed, the dy falls vertically downward and the balls have at most the locity which the bursting charge gives them. They probably e some of that, as it can be shown by measurement that a rapnel burst while suspended will give less velocity to the balls, an when fired with a strong support behind it. Therefore it nnot be depended on for great efficiency, although, in the base arged shrapnel, the velocity of the balls is the sum of the maining velocity and that due to the bursting charge. If in ing with high velocities the stopping of the projectile is not en, it is doubtless present and will influence the forward move- ent of the balls.

If this effect is sufficient to bring a shot with a velocity of from o to 130 metres to a state of rest it will decrease a velocity of o meters by a similar amount. Because the filling of the rapnel is not a homogeneous mass, the stopping of the body is ticed before the forward movement of the balls; this same ect is noticed when a gun is fired, the gun recoils before the ojectile moves.

In any case the force of the balls of the mortar shrapnel will t be much greater than that due to the bursting charge; this counts for the fact, that, while boards of 3 cm. in thickness are erced in an oblique direction when lying singly, a double layer boards 2 cm. thick will not be pierced but the balls found lying the under board; this is because they have not sufficient velocity, after piercing the first board, to overcome the elasticity of the one beneath it, which is increased by the bending in of the one above. For this reason extremely light lines of approach in sieges, and thin parapets in military field works are sufficient to protect the personnel against mortar shrapnel and infantry fire.

An interesting case of the recoil due to the bursting charge was offered by a small mountain mortar of 7.5 cm. The enemy were situated at a distance of 200 metres and 100 metres above the gun as may occur in mountain warfare with wild tribes. Shrapnel (reaching them nearly horizontally), was necessarily used as they do not fear shell; and a small charge being selected so as to give a velocity of about 50 meters, a shell was fired to get the time of flight, which was followed by a shrapnel; this was burst at the right time and the body of the shrapnel received such a recoil that, retracing the same curve, it fell into the battery. The velocity of recoil of this part was greater than 50 metres, it must have been fully 100 metres, the excess over the remaining velocity due to the charge in the gun bringing the body of the shrapnel back into the battery. Occasion is also taken to mention here that often, with low velocities which permit an easy observation of the flight of the projectile, a cloud is seen which clearly indicates the moment of iguition of the bursting charge by the fuze, then, after a longer or shorter interval, the explosion follows, which evidently shows that the time, from the transmission of fire to the bursting charge to the burst, varies from shot to shot. This phenomenon has no influence upon the direction of the axis of the shot, but the bad effects are shown in variations in point of burst which cannot be avoided even with the best fuzes. A similar case to that of shrapnel is shown by percussion shell in which the bursting charge is packed together by the shock of firing, and acts slowly so that at times shell with percussion fuze can be fired through several thicknesses of boards before explosion. This especially takes place in cannon with with high velocities.

The efficiency of a shot depends on two factors: striking the object, and the force of the blow. The hitting of a shrapnel depends on many things, some of which may be fulfilled in its construction and causes of inaccuracy avoided. For the following discussion it must be accepted that these conditions have been fulfilled and that it is fitted to fulfill its object. It must in every case be accepted; that the length of the projectile is sufficient for stability of flight; that it contains a large number of balls which are sufficiently heavy to be effective, and suffciently hard to over come obstacles without deformation. It must also be assumed that, the location and size of the bursting charge is the best found by experiment, and so arranged as to obtain the quickest possible action ; that the difficulties in regard to stability of flight are overcome ; that the balls are scattered uniformly through the sheaf produced by the explosion of the bursting charge ; in short, it must be supposed that the artillery possesses the best imaginable shrapnel for its mortars and howitzers.

It is impossible without these conditions to have the necessary confidence in it and we cannot at every fancy of some quill driver be willing to adopt a new one. Still this assumption is not so easily fulfilled as it is made, there are many different kinds of shrapnel; shrapnel the bursting charge of which lies in the head in front of the balls (obus à mitraille) with percussion or time fuze, in both cases the rear action may be artificially increased by small charges, and thus, in the case of the time fuze insure a free falling of the balls ; shrapnel of which the bursting charge is placed at the base, the shell separating in front causes the sheaf to be more compact and of greater depth ; other shrapnel the bursting charge of which, lying along an axial chamber, causes a hollow sheaf. (The base charged shrapnel will be the foundation for this discussion).

If we had at present the best shrapnel imaginable would an unquestionable success be obtained for the field howitzers and mortars?

In the first place this question must be answered in the negative, since the manufacture of a perfect mortar fuze has not been reached, and, as shown above, the time from the ignition of the bursting charge to the explosion is uncertain. The fuze will nevertheless be improved, though it may be long until the perfect form is reached. In consequence of the opinion, that the velocity of the balls is the sum of the velocity due to the bursting charge and the remaining velocity of the projectile, since it has been noticed that the recoil may be sufficient to entirely overcome the velocity due to the remaining velocity of projectile, it will be sought by means of some more powerful bursting charge to increase the velocity of the balls themselves, even though the velocity of the recoil of the body of the shrapnel be equally increased.

The difficulty of observation during battle will still remain, and the efficiency of this important means of fighting will be questionable, if the shrapnel from high angle guns cannot be fired almost as confidently as those from cannon. This efficiency can be reached, if a high training in this difficult kind of artillery fire is given and the rules laid down that covered targets are to be fired upon by shrapnel only with medium charges, to use full charges against uncovered targets or for dismounting guns, and to employ the smallest charges when using shrapnel as shell at short distances.

In this way, the sight can become so practiced, that delusions due to incorrect observation are overcome as much as possible, so that the greatest efficiency is obtained from the gun, and the presence of mind, so necessary in action, is retained. It must also be learned that shrapnel from high angle guns can never be used in rapid fire—because its weight and the small supply in the limber forbid it—and because its physical as well as moral effect depends on the large size of the bursting charge.

In yielding to the demand for a single charge for indirect shrapnel fire, the distinctive characteristics of high angle fire disappear and the question then comes up at once: Wherein lies the authorization for the introduction of the field howitzer and mortar? This special weapon will solve problems for the solution of which the cannon, on account of its high velocities and straighter trajectory, is not fitted.

The shells of the field high angle guns, (even if replaced by shrapnel for penetrating,) for use against military redoubts and and in similar cases of sieges cannot be replaced by those of cannon. It has been sought to use cannon in this way by reducing the charge, but this so called curved fire is entirely inadequate because of inaccuracy, the small charges burn with little regularity which varies greatly the initial velocity, to changes in which this kind of fire is extremely sensitive; and because the slight twist of the older rifled cannon places the stability of flight of the projectiles in question. This last condition is better fulfilled in the recent cannon by a considerable increase in the twist of rifling which more nearly meets the needs of the high angle fire—since a twist which gives stability with low velocities will necessarily do so with high ones. The penetration due to fall of a shell from field pieces is, on account of its slight weight, insignificant.

The accuracy of shells out of high angle guns is satisfactory with all charges. The observation of the shell is independent of atmospherical conditions. and the cloud of smoke from the bursting charge easily seen, being much larger than that produced by the shrapnel, this makes it easy to note the point of fall and gives a quick and satisfactory method of ranging the targets. In all high angle fire, the different charges should be used according to the distance of the objective and is true of shell.

Ordinary powder shells from cannon are not at all effective in front fire against shelter trenches, as a very large number of examples have shown, and shrapnel from cannon are not much more so, and even from high angle guns shrapnel are not always fully satisfactory.

It is for this reason that, the published trials of the efficiency of the different charges must be compared and a compromise made if possible.

As introductory are a few examples of the fire of cannon taken from the classical work of Lieutenant-General v. Müller, "The Effect of Field Guns, from 1815 to 1892".*

In this laborious work is given a most comprehensive review of the results of experiments in all countries with shell and shrapnel, investigated with painstaking care from every conceivable point of view, together with extracts from the most celebrated artillery writers from which can be obtained an idea of what to expect from them in time of war. Lieutenant-General v. Müller quotes (Pg. 182) from the French Colonel Langlois "All experiments to make use of shrapnel in high angle fire from mortars have been failures. All results obtained up to the present time have only confirmed this opinion."

This view is not agreed to in all its strictness, since it is not intended that shrapnel shall be fired in this way without special drill, and special regulations.

Respecting the execution of cannon, there are a great many experiments against ordinary targets, and against uncovered targets representing infantry and artillery under war conditions. These results are well known by nearly all artillerymen from their own practice.

Unfortunately there are but few examples among them in which covered targets were fired at. Among the latter the author took—page 48 from "*Giornale d'artiglieria*" 1883—a somewhat extended experiment against silhouette targets which was a part of the exercises of the Italian regiment, and which will serve as an example.

The trial was repeated five times at unknown distances—the results are placed in the following table:

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* Berlin, 1894. Ernst Siegfried Mittler und Sohn.

Target Practice with Italian 8.7 cm. gun, with shell and shrapnel, against artillery and Infantry targets, war conditions, 1882.

DISTANCE		SHOT		HITS		AV. PER SHOT		TARGET*
Shot sighted for Meters	True range Meters	Number	Kind	Total	Men	Hits	Men	
			I. Artillery without limbers.					
1120	1167	94	Shell	211	93	2.2	1.	Open (uncovered)
1270	1200	117	Shrapnel	223	105	1.9	0.9	Covered
1780	1804	92	Shell	120	74	1.3	0.8	Behind embrasures
1780	1780	103	Shrapnel	289	132	2.8	1.3	Open
2330	2340	95	"	247	123	2.6	1.4	Open
2410	2400	112	"	191	89	1.7	0.8	Covered
2445	2400	132	"	127	70	1.0	0.5	Covered
			II. Infantry.					
1230	1280	102	Shrapnel	224	136	2.2	1.3	Open line, kneeling (uncovered)
1295	1200	107	"	91	64	0.9	0.6	Open line, lying down
1790	1800	116	"	590	374	5.1	3.2	In line, kneeling (uncovered)
1790	1800	114	"	823	506	7.2	4.5	In line, standing (uncovered)
1795	1805	139	"	808	521	6.8	3.7	One line kneeling, Second line standing, } Cov'r'd.
2404	2400	132	"	585	430	4.4	3.3	In thick column lying down (uncovered)
2420	2344	122	"	1500	925	12.3	7.6	In thick column standing (uncovered)
			III. Cavalry.					
1825	1800	102	"	839	Horses 476	8.8	4.7	In line, (uncovered)

* The exact arrangement of these targets is not given in *Giornale d'artiglieria.*

This example selected with great care from a large number of experiments should give a realistic picture of the efficiency of the new artillery. It is not so overwhelming as the usual result, when taking a long wall as a target, would lead us to expect, and the number of hits is limited in a natural way, if the whole number of hits are not counted but only one in each man's breadth. This limitation naturally increases if the targets are separated by large spaces and conversely great width of sheaf is not of especial value, if only a single narrow target is offered to a single gun in firing position; the real value of breadth of sheaf ies in the fact that in an axial hit not too much is lost. One asily shoots over, if the shots are grouped too much, and thereore no statement gives an absolute representation of the efficency, and if we obtain even moderate results in practice it is not bad shooting.

While a guarantee of good efficiency and the possibility of a arge number of hits is indispensable, at the same time the arious results obtained on the target ranges, where this efficiency must be proven. and an effort will be made to obtain the greatest number of hits, must be gone over with great strictness and each xperiment examined with care as to its admission or rejection.

The above table shows the small efficiency of single shots from annon, if their effect is counteracted by skillful tactical formaions.

Yet the targets, with the exception of the last two against inantry in column, are chosen as unfavorable as possible, since only width of sheaf is demanded, while depth of sheaf, the peculiarly valuable property of the shrapnel, was not made the most of.

On page 51* of the book mentioned above is another example:

Firing with 8.7 cm. Ringshell against Infantry Targets.

The first target represented two companies abreast. In the numbers 1 and 2 was a firing line of 25 kneeling and 25 lying down infantry silhouettes in groups of five men each; 150 meters behind these came a support of 66 men. Each mans breadth taken as 0.6 meter; 180 meters behind the support came the main body, consisting of three targets behind each other, each target twelve men's breadth (0.6 meter). Number 3, had in the first line 18 standing and 18 kneeling infantry silhouettes, otherwise the same.

The target was more than 330 meters deep and the firing was executed against two targets, the line and the supports, since the bursting point was nearly always behind the first line.

On page 61,* are two Austrian target records made at Bruck in 1885, showing comparison between the efficiency of artillery and nfantry fire.

(*a*) Firing of 100 men from the army shooting school against a fully horsed and unlimbered battery of 8 guns. The limbers and horses standing covered from direct fire, 11.3 meters behind the guns.

(*b*) Shooting of a heavy field battery of eight pieces and a very well instructed Jäger company of 210 men against half a battalion of infantry 117 m. broad and 225 m. deep.

1. Skirmish line in groups: 116 lying down silhouettes (1/3

TABLE 2.

Number.	Range Meters.	Shots.	Target.		Hits mans-breadth	Hits Total	Hits Per shot
1	1150	20	25 kneeling silhouettes		5	39	2.0
			25 lying down silhouettes		3	12	0.6
			66 men supports	Standing	32	47	2.4
			36 men main body		7	8	0.4
2	1400	20	25 kneeling silhouettes		5	58	2.9
			25 lying down silhouettes		4	6	0.3
			66 men support	Standing	28	34	1.7
			36 men main body		4	4	0.2
3	1500	40	18 standing silhouettes		13	24	0.6
			18 kneeling silhouettes		7	21	0.5
			66 men supports	Standing	42	163	4.1
			36 men main body		4	4	0.1

figures) and 57 half figures, these pushed forward as a reinforcement to the line.

Fire	Range Meters	Shots fired	HITS			
			Total	% of shots.	In one minute	
100 shots	400	2050	488	28.8	122	Squad volleys, kneeling
4 Minutes	600	1683	170	10.1	43	Platoon volleys, standing

2. Remainder of the company, 50 half figures in a platoon behind the right wing as a reserve.

3. Battalion reserves, 230 half figures in half company columns 75 m. behind the company reserves.

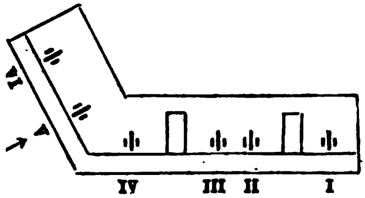
These figures show that such a disposition of troops at so short a distance before a coolly firing enemy is impossible. Tactics will therefore make the best possible use of artificial cover, and it is a question how to get at these covered troops since small arms and cannon are not sufficient. The problem falls to mortar shrapnel and torpedo shells.

Results of experiments at Krupp's works. (Lieutenant-General v. Muller page 52).

These trials took place with 12 cm. field howitzer and 12 cm. field mortar in August 1887. The target was taken to represent

FIRE	RANGE METERS	FIRED	HITS				
			Total	Per shot	Per cent of fragments	In one minute	Figures struck
Battery in six minutes	720	112 Shells	820	7.3	5.4	136.7	333
	1125	4 Shells 78 Shrapnel	1256	16.1	8.8	209	367
	1500	4 Shells 66 Shrapnel	462	7.	3.8	77	204
10 Jäger in three minutes	750	3011 Shots	315	—	10.4	105	174
	1125	1722 "	132	—	7.6	44	93

sunken battery of six guns, four of which were in a line oblique the front more than 45° while the other two were at right angles the line of fire. The object of this arrangement was to compare a frontal and half lateral attack of a defensive work, but it did not correspond to artillery targets in pitched battles as its lines were much stronger. This experiment is more valuable than ny other published account as a study of the effects of mortar hrapnel fire against covered troops, except possibly those in ifle pits, who are said to be covered to angle of fall of 30°.



Each gun had seven cannoneer silhouettes. The parapet was meters high, just inside which stood silhouettes 1.8 meters igh, they had cover to 22½ degrees—the men next to them were overed to 9° and 10°. In the oblique part of the battery, that , guns 1 to 4, the men at breastworks were covered under 15°, e other men at guns 1 to 3 were protected by traverses up to and 10°.

In order not to lose lateral hits, the flank guns 1 and 6 were red at least. The results were classified as follows:

(*a*) Number of men hit.

(*b*) Hits in same.

(*c*) Hits in battery, between men and four meters behind them.

(*d*) Hits in targets at breast height.

First.—Firing with 12 cm. howitzer August 1887. Shrapnel om 16.3 kg. to 16.5 kg. in weight filled, with 460 hard lead balls f 16 grammes weight or with 285 balls of 26 grammes, with a ursting charge of from 200 to 215 grammes of powder. The itial velocity with the 0.5 kg. coarse grained powder of $\frac{6}{10}$ mm. ranulation was 140 meters; with 0.6 kg. 161 meters; with 1 kg.

225 meters; with 1.5 kg. 290 meters, giving by accident the velocity of the shell from the Prussian 9 cm. gun of 1864.

Distance of bursting point measured from inner edge of breast works perpendicular to line of fire.

Firing at 1500 Meters.

Charge.	Number.	Weight of Balls.	Elevation.	Allowanee.	Length of Fuze.	Bursting Point.		HITS ON GUNS.								
						Over or Short.	High								Total.	Total in Battery.
Kg.	No.	G.	Deg.	P't.	Sec.	m.	m.		1	2	3	4	5	6		
	1	16	22.5	22	11	—40	16	a	3	1	2	5	6	—	17	77
								b	3	2	2	5	9	—	21	
								c	7	5	7	10	13	—	42	
								d	—	—	2	4	8	—	14	
	2	16	22.5	25	11	—60	15	a	—	1	—	2	4	1	8	34
								b	—	1	—	3	5	4	13	
								c	—	2	2	6	5	3	18	
								d	—	—	1	1	1	—	3	
0.5	3	26	22.5	22	11	—50	14	a	1	—	2	2	—	1	6	41
								b	1	—	2	4	—	1	8	
								c	2	4	3	12	5	—	26	
								d	—	—	—	5	1	1	7	
	4	26	22.5	22	11	—45	11	a	—	1	—	—	—	—	1	12
								b	—	1	—	—	—	—	1	
								c	—	1	—	3	1	2	7	
								d	—	1	3	—	—	—	4	
	5	26	22.5	25	11	—60	14	a	—	1	2	4	4	—	11	33
								b	—	1	2	5	4	—	12	
								c	—	1	3	9	7		20	
								d	—	—	—	1	—		1	
	6	26	8.6	8	6.5	—160	16	a	—	—	1	1	3		5	10
								b	—	—	1	1	5		7	
								c	—	—	—	1	2		3	
								d	—	—	—	—	—		—	
	7	26	8.8	8	7.0	—60	11	a	—	—	—	—	—	3	3	4
								b	—	—	—	—	—	3	3	
								c	—	—	—	—	—		1	
								d	—	—	—	—	—		—	
1.0	8	26	8.7	0	7.2	—25	4	a	—	—	3	3	2		9	41
								b	—	—	4	8	6		19	
								c	—	1	3	10			19	
								d	—	—	—	3			3	
	9	16	8.7	0	7.1	—40	8	a	—	1	3	6	2		12	54
								b	—	1	3	8			17	
								c	—	2	3	20	5		30	
								d	—	—	—	7			7	
	10	16	8.7	0	7.1	—45	8	a	—	—	2	5	4		11	55
								b	—	—	2	17	6		25	
								c	—	5	6	5	3		19	
								d	—	—	—	10			11	

At 1500 meters with 0.5 kg. charge, 43 cannoneers and 29 me at the breastworks were placed *hors de combat* in five shots; wi the heavy charge of 1.0 kg., 40 cannoneers and 21 men at th breastworks were put out in five shots. The battery received 19 and 164 balls.

Table B. Firing at 1980 Meters.

Charge.	Number.	Weight of Balls.	Elevation.	Allowance.	Length of Fuze.	Bursting Point.			HITS ON GUNS.							
kg.	No.	G.	Deg.	P't.	Sec.	Over or Short. m.	High. m.		1	2	3	4	5	6	Total.	Total in Battery.
	11	16	25.1	25	13.5	—50	0	a	Too short.							
								b								
								c								
								d								
	12	16	26.3	25	13.5	—60	23	a	Right, over. 88 at 33 distant.							
								b								
								c								
								d								
	13	16	26.3	40	13.5	—60	25	a	1	2	—	1	—	—	4	15
								b	1	2	—	1	—	—	4	
								c	2	3	5	1	—	—	11	
								d	—	—	—	—	—	—	—	
.6	14	16	26.1	50	13.5	—35	6	a	—	1	—	—	—	3	4	7
								b	—	2	—	—	—	4	6	
								c	—	—	—	1	—	—	1	
								d	—	—	—	—	—	—	—	
	15	16	25.4	30	13.4	—50	8	a	1	—	3	1	—	—	5	32
								b	1	—	4	1	—	—	6	
								c	9	8	6	1	1	—	25	
								d	—	—	1	—	—	—	1	
	16	26	25.4	35	13.4	—60	18	a	—	1	1	6	5	—	13	38
								b	—	1	1	7	8	—	17	
								c	—	—	3	5	9	1	18	
								d	—	—	—	1	2	—	3	
	17	26	25.4	40	13.4	—25	9	a	—	1	1	4	7	—	13	126
								b	—	1	1	7	30	—	39	
								c	—	—	5	24	43	—	72	
								d	—	1	—	4	10	—	15	
	18	26	25.4	40	13.4	—40	18	a	—	—	—	2	2	3	7	43
								b	—	—	—	2	4	3	9	
								c	1	4	—	8	7	9	29	
								d	—	—	—	1	4	—	5	
	19	16	12.1	12.0	9.3	—90	14	a	2	1	1	2	—	—	6	10
								b	3	2	1	3	—	—	9	
								c	—	—	—	1	—	—	1	
								d	—	—	—	—	—	—	—	
.0	20	16	12.1	12.0	9.5	—55	13	a	—	—	3	5	5	—	13	49
								b	—	—	4	13	6	—	23	
								c	—	3	4	11	8	—	26	
								d	—	—	—	—	—	—	—	
	21	26	12.0	12.0	9.5	—10	5	a	—	1	—	1	2	—	4	19
								b	—	1			2	—	4	
								c	—	—		8	7	—	15	
								d	—	—				—	—	
	22	26	12.0	12.0	9.5	—2	0	a	—	—			4	—	4	137
								b	—	—			8	—	58	
								c	—	—			79	—	79	
								d	—	—				—	—	

In firing at 1980 meters the smaller change of 0.6 kg. 46 cannoneers and 24 at the breastworks were put out in six shots; with

Table A. Firing at 1500 Meters.

Charge. kg.	Number. No.	Elevation. Deg.	Allowance. P't.	Length of Fuze. Sec.	Bursting Point. Over or Short. m.	Bursting Point. High. m.	HITS ON GUNS.	1	2	3	4	5	6	Total.	Total in Battery.
0.75	1	25.3	25	11.6	—75	22	a	—	3	1	2	3	3	12	45
							b	—	3	1	2	3	3	12	
							c	—	3	7	3	6	10	29	
							d	—	—	1	3	—	—	4	
	2	25.3	25	11.6	—55	20	a	—	2	4	3	3	—	12	65
							b	—	2	5	3	3	—	13	
							c	9	5	9	9	6	1	39	
							d	1	2	5	3	2	—	13	
	3	24.8	25	11.6	—60	16	a	1	1	2	—	1	—	5	56
							b	3	1	2	—	1	—	7	
							c	11	8	6	5	7	2	39	
							d	1	2	4	—	3	—	10	
	4	24.8	25	11.6	—60	14	a	—	1	2	2	1	—	6	21
							b	—	1	3	2	1	—	7	
							c	4	1	3	4	1	—	13	
							d	—	—	1	—	—	—	1	
	5	24.8	25	11.6	—70	16	a	2	—	1	6	1	—	10	46
							b	2	—	1	9	2	—	14	
							c	4	4	3	9	4	—	24	
							d	—	—	—	7	1	—	8	

Table B. Firing at 1975 Meters.

1.0	6	23	30	12.7	—75	18	a	—	1	1	4	1	3	10	68
							b	—	2	1	5	1	3	12	
							c	2	7	6	14	10	8	47	
							d	—	—	—	4	3	2	9	
	7	23	25	12.7	—80	20	a	—	2	1	2	3	2	10	68
							b	—	2	3	3	3	2	13	
							c	2	9	10	8	10	10	49	
							d	—	2	2	2	—	—	6	
	8	23	25	12.7	—70	22	a	1	1	3	—	—	—	5	42
							b	1	1	3	—	—	—	5	
							c	4	9	7	10	3	3	36	
							d	—	—	—	1	—	—	1	
	9	22.8	25	12.7	—65	16	a	—	3	3	5	3	—	14	67
							b	—	4	5	7	4	—	20	
							c	5	7	12	11	5	—	40	
							d	—	—	1	4	2	—	7	
	10	22.8	25	12.7	75	18	a	1	3	5	2	—	3	14	69
							b	1	3	7	3	—	3	17	
							c	8	13	9	9	5	2	46	
							d	—	1	3	2	—	—	6	
	11	22.8	25	12.7	—55	14	a	6	5	3	5	5	—	24	88
							b	6	5	5	7	8	—	31	
							c	10	11	12	5	8	—	46	
							d	1	1	3	4	2	—	11	

the larger charge of 1.0 kg. 27 cannoneers and no men at breastworks were put out in four shots. The battery received 261 and 215 shots and in addition a gun was disabled.

Second.—Firing with the 15 cm. mortar August, 1887. The shrapnel weighed from 31.53 kg. to 31.75 kg. and contained 500 hard lead balls of 26 grms. Bursting charge between 310 and 410 gm. Initial velocity with 0.75 charge 135 m.; with 0.9 kg. 153 meters; 1.0 kg. 163 meters; with 1.5 kg. 210 meters.

Table *A*. Firing at 1500 meters.
Table *B*. Firing at 1975 meters.

At 1500 meters with the smaller charge 45 cannoneers and 36 riflemen put *hors de combat* in five shots, and at 1975 meters with the larger charge of 1.0 kg. 77 cannoneers and 40 riflemen in six shots. The battery received at 1500 meters, 233 and at 1975 meters, 402 balls.

These results of the efficiency of the high angle guns demand careful consideration when taken in connection with the results of the cannon given above. It can be seen in the above firing that to shoot at a target of such little depth is entirely against the nature of shrapnel, in so much as breadth and not depth of sheaf will be effective, and consequently in the best firing, about a fourth of the balls fall in front of the battery, a fourth into the battery, and a half beyond it, or a fourth in it and three-fourths beyond it.

[Translated by First Lieutenant E. S. BENTON, 1st Artillery.]

HOWITZERS AND MORTARS FOR FIELD ARTILLERY, TO SUPPLY A NEED OF CURVED FIRE.

By Tiedemann, Major and *Abteilungs-Kommandeur* in the Posen Field Artillery Regiment, No. 20.

Jahrbücher für die deutsche Armee und Marine, November, 1897.

B. Measures adopted during the present decade as a result of the foregoing considerations.

I. GENERAL VIEW.

The experience of the Russians, especially at Plevna, as to the inadequacy of their light artillery gave rise to a general endeavor to make up the deficiency. It was remarked on all hands that unless something was done in this line, a war in the future would probably be unusually prolonged, since a considerably inferior force by throwing up intrenchments could hold a much larger force at bay, and keep it from engaging in a decisive campaign.

When rifled guns had first been adopted, many States, as France, Austria and Germany, had retained reduced charges for the new guns, in order also to be able to use them after the fashion of howitzers. But this had to be given over, for the small charges burning ununiformily in relatively large powder chambers gave variable initial velocities to the projectile. Besides this, the twist of the rifling of the field guns was too small for the initial velocities that were attained, so that the stability of the axis of rotation of the elongated projectiles suffered. As a consequence of both these defects, projectiles thus fired went wild, and hence reduced charges were abandoned.

When at Plevna it again became a question of reaching targets protected against the angle of fall of flat trajectories, recourse was once more had to reduced charges, hoping thereby to preserve that simplicity in the artillery system which is so necessary for an army in the field. The attempts to obtain this end by shrapnel at high angles proved fruitless though long continued (1886-1888). The point of burst of the shrapnel was very variable, and as a consequence the effect against targets protected against

15° to 22° was extremely small. With protection against 15° fall, under favorable conditions, and after a large number of rounds, from $\frac{1}{7}$ to $\frac{1}{4}$ of the targets used were struck. On an average one-half a bullet hit for each round. The firing consumed much time, as the rate of fire was slow, and observation of the shots difficult on account of the little amount of smoke from the bursting shrapnel. Since no tactical effect in the field was to be hoped for (the tests agreeing with calculation) the trials were abandoned. The impossibility of thus solving the problem was shown by Rohne, then Lieutenant-Colonel, in a paper published in 1887, entitled. "What may field artillery expect from the use of reduced charges?" (*Archiv für die Artillerie und Ingenieur Offiziere.* 94. *Band*). The author at the same time proposed the employment of field howitzers or mortars for seeking out concealed targets.

There remained now but two ways to compass the desired end; one was to use howitzers and mortars in light artillery, the other was to use projectiles which, though carrying a bursting charge, could be fired at light initial velocities along a flat trajectory, and be able to hit concealed targets by the disposition of the bursting charge.

II. RUSSIA.

The Russians who felt so keenly the insufficiency of their field guns in the war of 1877-78, and who learnt at Plevna the value of field intrenchments for the defense, have since adopted field mortars for their field army.

They have now 24 batteries of field mortars, with six pieces to a battery. The batteries are organized into five regiments of four batteries each, and two regiments of two batteries each. As the first two regiments were created in 1889 and the number of regiments has been increased year by year, it does not look as if the limit were yet reached. This seems the more likely as regiments number 6 and 7 contain but two batteries apiece, whereas if 24 regiments had been considered sufficient for the army, it seems probable that but a single sixth regiment would have been created having four batteries, as the other five regiments have.

The regiments first organized were assigned to the military districts of Wilna and Kiew.

The strength of a regiment is as follows (the battery being shown in parenthesis):

	Officers.	Men.	Horses.	Pieces.	Ammunition Carts.	Caissons.	Supply Wagons.	Other Vehicles.
Peace	25 (4)	689 (52	261	24 (6)	24	72	4	43
War	25 (4)	862 (109)	756	24 (6)	24	72	4	44

Besides the large number of 18 caissons each mortar battery has 6 ammunition carts drawn by a single horse. The gun carriages have six horses, the other wagons four. The regimental wagons consist of 6 one-horse vehicles (3 officers' carts, 2 apothecary and one hospital cart); 31 two-horse vehicles (3 regimental pack wagons, 12 regimental artillery supply wagons); 1 three-horse vehicle (headquarter wagon); and 6 four-horse vehicles (2 ambulances, 4 battery tool wagons).

The total weight of a fully equipped mortar without connoneers is 2100 kg. (4620 lbs.), or 350 kg. (770 lbs.) per horse; this is greater than that of the German field gun. The limber carries twelve projectiles, the ammunition cart four, the caisson twenty-eight.

The ammunition cart is for bringing up ammunition to the battery from the ammunition park. The employment of this intermediary seems to indicate that the caisson is too heavily loaded for four horses, to be certain of moving across fields. For each mortar, there are 92 rounds provided in the battery, so that the total ammunition supply of a battery amounts to 552 rounds. The projectiles, shrapnel and torpedo shell, lie in hand barrows which are used in loading them into the caisson; special boxes for transportation are also used for the powder charges.

The mortar is of steel, 15.24 (6 in.) caliber, wedge lock and oblique vent. It is 9 calibers long, with bore 7 calibers long: weight, 460 kg. (1012 lbs.). The tube and jacket are connected by a locking ring; the piece has no preponderance. On the face of the right trunnion is a rack for giving elevation. The shrapnel weighs 31 kg. (68.2 lbs.), with steel body which is thicker towards the base. The bursting charge weighing 247 g. (8.7 oz.) is situated in the base contained in a steel cup with rim towards the base of the projectile. From this cup runs an iron tube connecting through an orifice with the combination fuze. The shrapnel contains 720 balls of hard lead in a sulphur matrix. The fuze burns 28 seconds. The projectile has two copper rotation bands.

The torpedo shell is of steel weighing 26 kg. (57.2 lbs.), with a bursting charge of 4.88 kg. (10.7 lbs.). It has but the percussion fuze, and one centering and one rotation band.

Three powder charges are at present used, consisting of coarse grained powder; their weights are 1.74 kg. (3.8 lbs.), 0.87 kg. (1.9 lbs.) and 0.435 kg. (.96 lbs.). The largest of these charges imparts to the shrapnel an initial velocity of 220 m. (721 feet), to the torpedo shell an initial velocity of 232 m. (760 feet); the maximum range is 3200 m. (3500 yards).

The cylindrical body of the shrapnel is not broken up when its charge explodes, so that the bullets and head are projected as from a small mortar. Their velocity is increased by the bursting charge, but the lateral distribution is not great. The difference in weight of the two species of projectile is not practical as it requires a separate range table for each.

The carriage consists of the chassis, the steel axle with rubber springs, the wheels and the support. The cheeks of the chassis are of sheet-iron, and approach each other towards the trail, being held apart and in place by iron transoms. The trunnion beds are made especially strong that the cheeks may withstand the great thrust. A worm engaging in the segmental rack on the right trunnion gives the elevation.

The steel axle lies forward on the chassis; the cheeks of the chassis have a motion downward on the axle, and are connected through bolts with the axle buffers, which consist of six caoutchouc disks with iron disks between. Upon firing the cheeks press downwards on the axle, and the thrust from the powder gases is thence communicated to the supports, which are raised during transportation but let down when firing begins. These supports are provided with buffer disks and rest on the ground. By these means the axle and wheels are as far as possible relieved from the great downward blow on firing.

The gun in firing is 1.1 m. (3½ feet) from the ground, this permitting elevations from + 47° to − 18°.

The Russian reports of comparative tests in 1891 between mortars and field guns are very instructive. According to these reports, at ranges of 1500 to 2300 m., the mortars firing shrapnel were far superior to the field guns against targets representing cannoneers behind the parapets of a field work. A further bombardment of the work by mortars firing torpedo shell at 1800 m. made an easily practicable breach through parapet and over trench. The havoc in the works was of such a character that it is not likely the garrison could have held the position to the end of the infantry attack. The blindages constructed in the trenches behind the parapets were likewise unable to withstand the force of the torpedo shells. In another trial with the Russian 15 cm. (5.9 in.) field mortar against targets protected against the flat trajectory of field guns, 112 out of 225 of the silhouettes were hit at a range of 2500 meters in 108 rounds (62 shell, 46 shrapnel). The number of bullets that struck as well as the exact angle against which the targets were protected is not stated. In another trial, at 1650 meters with 115 rounds (70 shell, 45 shrapnel), 180 silhouettes out of 225 were struck; of these 180, there were 86 not behind cover.

To still further try the question whether a mortar battery might fight a field gun battery in the open, comparative trials were made with these two species of cannon at 2100 meters range. Firing at an unprotected battery with 112 targets, 56 targets were struck by the field guns after 74 rounds, with 346 bullets hitting; at the same targets the mortar battery struck 109 of the figures after 65 rounds, with 2668 bullets hitting.

This result which at first glance is decidedly in favor of the mortar battery is not, however, entirely free from objection. Both batteries should have been permitted to fire for the same length of time. Had this been done, the ratio of the number of rounds delivered would have been for the field guns relative to the mortars as 5 to 1, making a far more favorable case for the field battery. The mortars with this condition would have fired, let us say, fifteen rounds, with a probability of 27 figures struck, and 600 bullets hitting.

Calculatiing the weight of ammunition expended by field guns and mortars, and using the figures of the actual firing, we find for the field guns for 1 kilogram of iron expended, 0.09 target struck with 0.59 bullet hitting; for the mortars, on the other hand, for 1 kg. of iron expended, we find 0.05 target struck with 1.02 bullet hitting. The case thus stands more favorably for the field battery with respect to the number of cannoneers hit, even were the mortar battery able to deliver 65 rounds in the same time that the field battery fired 74 rounds.

Lieutenant-General Engelhardt, of the Russian service, who has given much attention to mortar construction, has declared, perhaps with a touch of optimism, that the question of field mortars has been best solved in Russia. Their mobility has been proved in the Rowno maneuvers; when marching with the Cossacks, they have never been left behind. This good mobility has been attained in spite of the large calibers, which have the advantage of the large number of shrapnel bullets to each projectile.

That there is a difference of opinion in Russia respecting field mortars is to be inferred from the following sentences in a paper by General Engelhardt: "A discussion of the advisability of substituting the 12 cm. (4.7 in.) for the 15 cm. (5.9 in.) mortar is unseasonable; for our mortar in spite of its large caliber is the lightest. It has nearly every advantage. To be sure it has one defect that its maximum range is but 3200 m. while other countries have pieces of equal caliber firing 5 kilometers; but this can be remedied by using smokeless powder with some necessary changes in consequence in the carriage. Were this done, our mortars would be superior to those of other states."

The General is thus of the opinion that the field mortar must be a long range cannon, and indeed thinks that it will frequently be the case that it can be used only at long distances. But this requisite the present model by no means fulfills. If a mortar battery can find no cover and must contend with a field battery, the calculation made above of the hits per kilogram of iron shows clearly that it must do so at a disadvantage. From this arises the demand that the mortar shall have a range up to 5 km., a condition that the Russian mortar to the present time has been far from satisfying.

General Engelhardt is of opinion that thanks to the employment of the ammunition carts, the conveyance of the heavy projectiles from the ammunition park to the guns is now assured. The use of these carts seems to indicate that the four-horse caissons lack mobility; the assignment of six ammunition carts to six pieces evidently means that each piece will have its ammunition brought up by one cart. The first round will be taken from the six limbers. While this round is loading, four of the limbers will return to the ammunition park, and the other two stay with the pieces (numbers 2 and 5). The carts each carrying four rounds will now come up and take a position behind the pieces, and furnish the four following rounds for each mortar. At the rates of one shot a minute per battery and two per minute, the carts will be empty in 24 and 12 minutes respectively; when this occurs, the carts return to the ammunition park, are again loaded, and return once more to the guns. During their absence the mortars draw their ammunition from the two limbers that remained by them, and these when empty are replaced by two full limbers. In any case, even though the method of supplying ammunition may not be just as outlined here, the continual coming and going of the carts in moderately open country will not remain unnoticed, but will assist in discovering the position of the battery when it is otherwise concealed.

From all the facts relative to the Russian field mortars the following conclusions may be drawn respecting their employment:

1. The mortar batteries are deficient in mobility. Many opinions agree in this; the mortar batteries have blocked the way of the other troops, and of course, in this connection, it is of no moment whether it was the pieces or the ammunition wagons that constituted the hindrance. All the parts of a field battery must be equally mobile. With the Russian caissons this evil might be corrected by using six horses.

2. The batteries with their great number of vehicles take up so much space in the column of march, that it becomes necessary to place them in the rear, that the other troops may be brought into action seasonably.

3. At the beginning of the artillery duel, the mortar batteries will not be able to participate on the grounds stated in 1 and 2, as well as for the reason that the artillery contest will probably open at ranges too great for the mortars, or at which their inaccuracy will be excessive.

4. On account of their marked inferiority in rate of fire, the mortars will not dare to engage with field guns, since the mortars must inevitably be worsted, unless they are concealed or protected. Besides the mortar battery consumes from eight to ten minutes between unlimbering and firing of the first shot.

5. The manner of bringing up the ammunition requires a position for the mortar batteries concealed from the enemy's view.

6. The long time between unlimbering and the first shot (and this evidently will not be less in limbering up) requires likewise a concealed position.

It seems probable therefore that in a battle, these batteries will only come late into play, when the field gun batteries have slackened after a long duel, and shelter trenches are to be bombarded before the decisive infantry attack. It would be a wasteful and improper use of the limited, and not easily replaced, ammunition of the mortars, to use it against such targets as could equally well be bombarded by field guns. On the march therefore the mortar batteries belong to the rear of the column, in an engagement they are at first with the reserve, and do not come into action until the place is fixed against which the main attack is to be made. Against this point the mortars open from concealed positions, supported by the field guns which unite their fire against the same objective.

Their employment as light siege batteries seems also to be had in view; the Russian army would thus have at hand 144 of these mortars for siege purposes.

III. FRANCE.

After France had fortified her eastern frontier after 1870, the first steps taken were with a view to the defensive in the event of a new war with Germany; at times, however, consideration was also given to the idea of assuming the offensive and besieging the enemy's fortified places. The rapid mobilization in Germany made the French look to the defensive as their part; on the other hand the confidence the French had in having created a stronger army encouraged them in the idea of taking the offensive,

So Russia's example has been followed, and a curved fire gun has been introduced into the field army, in this case a 12 cm. (4.72 in.) howitzer. The number of these batteries is not known, but they have been assigned to several of the Army Corps in divisions of two batteries each. The battery consists of 6 howitzers, 9 caissons, one field forge, one provision wagon, drawn by six horses; there are also in each battery one luggage and one forage cart, each drawn by two horses. The limber carries 16 shrapnel; four of the caissons carry shrapnel, and the other five shell. As the body of each caisson holds 32 rounds, each battery is supplied in all with 288 rounds of shrapnel and 240 rounds of shell. This makes 88 rounds for each howitzer. The ammunition column for each division carries in addition 800 rounds, with the same ratio of shrapnel and shell as in the battery. The projectiles are stowed in two layers, with the powder cartridges above in chests.

The carriage of the 12 cm. howitzer consists of an upper and lower part. The piece is of steel, 14 calibers long, surrounded by a jacket on which are the trunnions supporting the piece on the carriage. Parallel and under the piece is a bronze cylinder with a hydraulic recoil apparatus. This cylinder connects with an air chamber, and is joined to the piece through the locking ring; the air chamber is screwed into the jacket.

Upon discharge the piece moves back inside the jacket carrying with it the recoil cylinder, from which the oil passes through a valve and compresses the air in the air chamber. The piece is thus brought to rest; the compressed air then expanding and forcing out the liquid returns the cylinder and with it the piece to its original position. The maximum possible recoil for the piece within the jacket is 475 mm. (1.9 ft.).

The piece itself weighs 550 kg. (1210 lbs.), jacket and recoil check together 140 kg. (308 lbs.), the carriage 785 kg. (1727 lbs.), and the limber (1958 lbs.), so that the total weight of the howitzer without the cannoneers mounted upon it is 2365 kg. (about 5200 lbs.). Without cannoneers therefore it is as heavy as the German field gun carrying them.

The recoil cylinder, which considerably augments the weight of the piece, is intended to return the gun to its original position, so that the howitzer may be used as a species of rapid fire cannon. It looks as if this portion of the piece was very easily susceptible of derangement, for though according to French accounts the cylinder needs refilling only after 1500 rounds, there are nevertheless two precaution arranged to permit a continual observation of the state of the cylinder. First of all a pin is placed 420 mm. (16.5 in.) from the front end of the jacket, along the path of the tube. If the piece recoils in the jacket more than this it breaks or bends the pins. The fire may however be kept up until the recoil is stopped by a ring of rubber buffers about the tube. By means of this ring the tube is prevented from breaking through the rear of the jacket when the recoil apparatus is rendered unserviceable in the course of firing or damaged by the enemy's projectiles.

The lower part of the carriage has wheels 1.36 m. (4½ ft.) in diameter, a wheel tire brake for use during transportation and a prong attached to the trail to take up the recoil on firing. When the piece is limbered up this prong is only 37 cm. (14½ in.) from the surfase of the ground, so that it can easily be struck in passing over broken ground and cause injury. When firing the prong sinks firmly into the earth and takes up the recoil gradually. The recoil cylinder serves to lessen the shock, which would be very great were the recoil entirely arrested, and would heavily tax the carriage.

The use of the prong making it difficult to alter the direction of the carriage; the upper part of the carriage is pivoted on the lower part, so that the fire may be rapidly distributed along the objective. The howitzer can thus be traversed 5½° to either side, the motion being given by a crank wheel and toothed arc. Elevation is given through a toothed arc on the right trunnion. In transportation the top carriage is secured firmly to the lower part.

The rate of fire is usually 3 rounds per minute, with six rounds per minute for rapid fire. This rather slow rate of fire, which was not to be expected from the character of the carriage, is due to the construction of the howitzer. The breech mechanism requires that the muzzle be depressed for loading so that the elevation of the axis of the bore shall not exceed 7°. As such small elevations are not usual in howitzer firing, time is necessarily consumed in sinking and raising the muzzle.

In addition, the recoil cylinder must be observed after each round. Nor is there any security against premature discharge, or a too early opening of the breech. This last is important because French powder sometimes flashes up again when the breech is rapidly opened. The nature of the breech mechanism (screw fermeture) likewise makes rapid fire impossible as it demands a constant observation of the plastic gas check.

The height of the trunnions is 1.1 m. (3.6 ft.); the elevation possible for the howitxer reaches from −5° to +45°.

The shrapnel is of steel, with a chamber at the base and one in the head. The rotation band is of copper, the bursting charge is 280 g. (10 oz.) of small arm powder, and the filling is 670 balls of hardened lead weighing 12 g. ($\frac{3}{7}$ oz.). The fuze is a combination one. The weight of the shrapnel is the same as that of the shell 20.35 kg. (45 lbs.). The shell is four calibers long (*obus allongé*); it is made of steel with thin walls, carries 6 kg. (13 lbs.) melinite, and has only the percussion fuze. It is designed for use against objects with considerable resistance. Far less effect is expected from the faagments of the shell upon explosion, which are but a few strips, than from the enormous compression of the air resulting from the detonation, which is certain to cause serious internal injury to every one around if the shell bursts in a confined space. It is not yet known how great its sphere of action is, but there can be no doubt that this projectile will have a terrible effect on the nerves. The melinite shell will undoubtedly be very effective if it strikes near the target; it will be of especial value against earth-works, and for overthrowing weak stone walls by the air stress, as well as for breaking through stronger wooden defences.

Of course there is a possibility of the shell exploding in the bore, which would destroy the gun and kill all in the vicinity. The chances of such an accident, it is true, have been much reduced by a care in the construction of the projectile, and besides this the initial velocity of the projectile of a howitzer is always small. There is a further security against premature detonation in the exclusive use of the percussion fuze.

The cartridges are in the form of four sided prisms containing 220 and 330 g. (8 and 12 oz.) of smokeless powder, and give by putting them together the maximum charge 550 g. The calculated initial velocities for these three charges are respectively 173, 217 and 290 m. (567, 712, 951 ft.); using percussion fuzes the maximum ranges are 2600, 3800, and 6000 meters; using time fuzes with a maximum time of burning of 22 seconds, 2600, 3450 and 4850 meters.

The two smaller charges, which together make the service charge, are put up in bags of different colors, so as not to get them confused when they are used separately. To make the conditions of loading uniform when only one cartridge is used, and thus avoid variation in the powder pressures, a paper cylinder of the same length as the cartridge omitted is inserted in the mouth of the cartridge used.

The limber of the 12 cm. howitzer is similar to that of the French 9 cm. field gun. The door of the limber chest opens backwards and rests upon the rear foot board for the cannoneers. The projectiles lie in two rows over one another in prepared spaces; projectile cases are not therefore employed. The cartridges lie on top in sacks containing eight apiece; here also are the fuzes, and compartments for other accessories. The opened door of the limber chest serves as a table to hold the small cartridges.

There is some difference in the accounts as to the distribution of the cannoneers in transportation. According to one account two men are carried on the axle seats of the carriage, two on the limber, and two on the caisson limber; another account says that five men are carried on the limber of the piece, and when necessary even six. For the service of the howitzer, a gunner and six men are required, three are for the service proper, three bring up ammunition, and one looks after the ammunition and properly proportions it.

Three of the caissons filled with shrapnel take their place behind the howitzers when these are disposed for action; the limbers are kept under cover. A caisson with melinite shell may replace one of the shrapnel caissons. The interval between howitzers in position is 13 m. (14 yds.), but this may be reduced according to the nature of the country to 4 m. (4½ yds.). As the number of howitzers is limited, this close order seems to mean that the howitzers are habitually to take up a covered position, and thus withdraw from the direct fire of the hostile field guns.

The manner of firing the howitzers is similar to that of the field guns.

The elevation is generally given by means of a quadrant on the jacket, which remains in place even while firing. A sight is also provided, but cannot be used for elevations greater than 13° ; it will be used for rapid fire in the first line. A crank for changing the elevation rapidly alters the elevation by 4°. The gun may be laid in azimuth by the sight or by a plumb line, or by a rule laid against the left trunnion. This last has a spirit level attached to indicate difference in level in the wheels; it has a shorter line of sight but a greater horizontal field than the sight, and can be used at all elevations, and during the loading of the piece.

Batteries equipped with the 12cm. howitzers have their men instructed in the service of the field gun as well as of the howitzer. In artillery regiments not containing howitzer batteries, the men will nevertheless be instructed in the service of this piece in the second year of their enlistment. It is thus the intention to attach the howitzer batteries to the field artillery regiments, though all the regiments do not contain such batteries.

Data of firing tests of these guns have not been published, That they have been criticized unfavorably in certain circles is not conclusive against them, for many were dissatisfied with rifled guns when first introduced.

From the facts that we do know, we can conclude that the howitzer has a good deal longer range than the Russian 15 cm. mortar. The shrapnel of the French piece which contains nearly as many bullets as the Russian will be almost as effective; the melinite shell is much better than the corresponding Russian shell.

Among the defects of the piece may be mentioned that it is too heavy for covering long distances on the field (the piece with five cannoneers weighs 2755 kg. (6060 lbs.) and the caisson about the same); other defects are that the recoil cylinder is easily injured; that a blow from the gun on the jacket may disable the piece; that the prong increases the weight of the trail, impeding the limbering up, and also makes any considerable change in direction difficult. Moreover the fermeture, together with the position of the bore in loading, and the absence of a graduation for range on the sight, makes rapid fire out of the question. The piece is indeed of excellent construction, but very complicated.

The howitzer batteries for these reasons will probably seek covered positions when engaging in the artillery duel at medium ranges, yet they will be able to take part in this contest from the long ranges at the very start. The large amount of shrapnel allotted them points to their employment in the artillery duel. When the enemy seeks cover from the field guns behind works of high profile, the howitzers will probably use the melinite shell to destroy the earthworks and kill those in the neighborhood of its burst. On account of the small depth of such targets the howitzers will probably push forward to medium ranges to attain accuracy and in so doing will take cover to escape the field guns.

In spite of the prong the recoil is not entirely checked, for in certain trials in yielding ground (and this must generally be reckoned on), the recoil amounted to 96 cm. (38 in.) for the first round, 40 (16 in.) for the second, and 28 (11 in.) for the third. In the last, the trail sunk into the ground.

According to the "Regulations for the service of the artillery in the field," the howitzer divisions will be assigned to the separate armies according to the army's task. It is optional with the commander of the army either to attach them to a corps, or to keep them under his personal orders.

IV. OTHER FOREIGN COUNTRIES.

In other countries within and outside of Europe, the example of Russia and France has been followed, and mortars and howitzers have either already been introduced into the field service, or steps have been taken leading to this introduction.

Italy has adopted a 9 cm. field mortar (3.54 in.), but this cannot have much effect on covered targets.

Turkey has twelve howitzer batteries (12 cm., 4.7 in.), organized into 2 regiments each with 2 divisions of three batteries. The war footing of a battery is 4 officers, 144 men, 88 horses, 6 cannon and 14 wagons.

Japan employed field howitzers at Port Arthur, but accurate information is lacking as to the caliber or the effect produced.

Denmark has tested a 12 cm. howitzer in a field carriage, and Spain and Bulgaria have followed on the same line.

In England a 127 mm (5 in.) field howitzer has been adopted. The piece is 10 calibers long, weighs 483 kg. (1063 lbs.), has screw fermeture, plastic gas-check, and axial vent. The carriage weighs 1165 kg. (2560 lbs.), the limber with 21 rounds weighs 1120 kg. (2460 lbs.), the piece with cannoneers 2465 kg. (5420 lbs.), the caisson with 45 rounds and with cannoneers weighs 2490 kg. (5480 lbs.). The projectiles used are cast-iron shell with percussion fuze and gunpowder bursting charge, and shrapnel with base chamber, and combination fuze, and also canister;

the projectile weighs 22.7 kg. (50 lbs.). The smallest charge is 107 g. (nearly 4 oz.) of cordite. To this cartridge may be added three smaller cartridges of 72 g. each, so that there are four possible charges of 107, 179, 251, 323 g. (say 4, 6½, 9, 11½ oz.). Using the greatest of these powder charges, the initial velocity is 248 m. (815 ft.) with a maximum range of 4500 meters. The time fuze however cannot be used beyond 3100 meters. To each battery belong 6 howitzers, 9 caissons, 1 field forge (all six-horse), and six four-horse wagons.

The construction of the piece resembles that of the French howitzer. The gun lies in a bronze cradle with trunnions which support it on the carriage, and can glide for a certain distance within the cradle in the direction of the axis of the bore. Two hydraulic cylinders and two cylinders with springs return the piece to its first position after firing. The piece is fired by an obturating primer.

The carriage permits of elevations from —5° to +45°. The latest accounts do not say whether the spade under the axle to check the recoil has been retained as formerly.

In our opinion the piece is too heavy, and the latest technical advances in gun construction have not been utilized.

Trials with a 12 cm. howitzer were made in Austria, but these have been discontinued. When curved fire is needed in the field, the Austrians propose to use the 15 cm. mortar and howitzer siege batteries that follow the army. Whether this is possible is very doubtful on account of the rapid progress of a campaign, and the weight of these cannon,—the Austrian 15 cm. howitzer weighs 1062 kg. (2336 lbs.), and the carriage is also heavier than that of the French 12 cm. howitzer. These pieces, difficult to move across country and sure to stick in wet ground, will not in action be brought at the right time to the right spot.

Switzerland in her "Position artillery" has 12 cm. mortars on field carriages, with movable platforms. The weight, 2208 kg. (4860 lbs.), is greater by 200 kg. (440 lbs.) than the German field gun. With 41° elevation the maximum powder charge (.9 kg., 2 lbs.) gives to the 18 kg. (40 lbs.) projectile an initial velocity of 285 m. (935 ft.) with a range of 4600 m. The limber carries 10 shell and 5 shrapnel, the rear carriage of the caisson three times as much. The piece is much thought of in Switzerland.

[Translated by Second Lieutenant *George Blakely*, Second Artillery.]

(TO BE CONTINUED.)

HISTORY OF THE SEA-COAST FORTIFICATIONS OF THE UNITED STATES.

V. EARLY FORTIFICATIONS AROUND NEW YORK CITY.

Reprinted from The Military Papers of Daniel D. Tompkins, Governor of New York, written during the second war with Great Britain.—Edited by Hugh Hastings, State Historian.

A GENERAL HISTORY OF THEM—SANDY HOOK AND THE NARROWS FROM EARLIEST TIMES REGARDED AS NATURAL POSITIONS FOR DEFENSE AGAINST AN APPROACHING ENEMY.

The strip of deep water, which divides the Long Island and Staten Island shores, called the Narrows, has always from earliest times been regarded as the most natural approach to Manhattan Island. Through this strait passed the "Half-moon," Hudson's eighty-ton vessel, that brought him across the sea to discover the magnificent stream that now bears and for all time will bear his name. Four years later, the first enemy that approached New York, used the Narrows, Samuel Argall, Governor of Virginia, who had destroyed the defenseless French settlements of Acadia and who now dropped in to pay his respects to the Dutch Governor, Hendrick Christiaensen. Argall demanded a surrender and Christiaensen promply complied. New York city at that time consisted of four houses, whose tenants offered no resistance to the Englishman and his armed ship.

The first record of fortifications on or around Manhatten Island is found in 1614. One or two little forts had been constructed by the Dutch, who maintained a small garrison to transact trade with the Indians. Between 1623 and .633, the incorporated West India Company built four forts in the New Netherlands, one of which was at New Amsterdam (New York City), the other at Orange (Albany).

In 1643 complaint was made by the settlers to the State's General of the New Netherlands that Fort Amsterdam was utterly defenseless, "and stands open to the enemy night and day."

The first marked instance of the loyalty, disinterestedness and generosity of New Yorkers is found in the Colonial Records covering the year 1653. Even at that early period the budding success of the province, due to the thrift and enterprise of her Dutch inhabitants, exited the cupidity of the Yankees of New England. The war prevailing between England, which was then under the control of Oliver Cromwell's government, and the States of Holland, gave the Puritans the opportunity to recommend that the English Protector should organize an expedition to capture New Netherland.

The English appetite for conquest, always insatiable from time out of mind, bit at the opportunity to grab the province of New Netherland and the expediton against the Dutch was ordered, the objective point being New Amsterdam. All emigrants, upon arriving in this country, had been given the strongest assurance by the Dutch West India Company of protection against the common foe. While they were expected and were willing to defend their homes againts the assualts of invaders, they had been assured, and they believed, they should not be required to work on the defenses or to render financial contributions to that end.

The dilemma in which they now found themselves was not only perilous, but threatened disaster to the province. The only alternative presented to them was to obey the behest of the Dutch Governor, Pieter Stuyvesant, or to surrender the province without a contest. No time was left for crimination, explanation or protest. The inhabitants set to work with a will to build the historical palisades or stockade from the East to the Hudson river, along what is now the northern limits of Wall street. They also aided in the construction of works of defense along the shores of the East and Hudson rivers. Nor did they stop here. With no other security than the say so of patriotic citizens, a liberal loan was raised, the home government forcing this responsibility upon the province.

The patience of the loyal people was about exhausted; and when Governor Stuyvesant served notice that the burgomasters and schepens of the city were expected to supply the fortress with provisions, in addition to all the contributions they had already made, there was open revolt. The Governor was as stubborn as they. Their demands for equity and protection were refused. In retaliation they resisted the unreasonable encroachments he had attempted upon their liberty. The outcome of the squabble would have been highly interesting, had not information arrived that as the English fleet was about to start from Boston, news had been received that peace between England and Holland was restored.

Out of this apparently insignificant episode dates the history of excise in the city of New York. The tapsters' excise on wine and beer was the source of substantial revenue to government. To meet the expenses of the city works which amounted to 16,000 florins or $6,400, computed in the currency of to-day, the citizens requested Governor Stuyvesant to transfer that amount from government's fund to the credit of the city. The testy Governor stumped with his wooden leg, ridiculed the proposition and abused the proposers. The city authorities were insistent, and in 1658 a satisfactory compromise was agreed upon, the government having yielded concessions to the city in other matters.

The English fleet that brought over Colonel Richard Nicolls in 1664 to subjugate the Dutch in New Netherland—the fleet consisting of four ships and four hundred and fifty regular troops—approached the city by the ways of Sandy Hook and the Narrows. Elkins, a Dutch governor, who came out the year after Christiaensen's submission, had thrown off all dependence on the English, with the result that the province continued under Dutch jurisdiction until Colonel Nicholls appeared on the scene. Governor Pieter Stuyvesant, who had taken office in 1647, though choleric and unbearable, was a courageous man and a determined soldier. He declared his intention to fight the English. The local authorities implored the high-strung governor to submit, and the province with all its dependencies was surrendered to the English.

The garrison retired with all their arms flying and drums beating; "and," says the chronicler, "thereby the English, without any contest or claim being before put forth by any person to it, took possession of a fort built and continually garrisoned about forty years at the expense of the West India Company."

The garrison, at the time of the surrender, consisted of one hundred and eighty soldiers, and twenty-four pieces of artillery. Pieter Stuyvesant, in his answer to the comments of the West India Company on his report on the surrender of New Netherland, describes the fort as follows:

"First. The fort is situate in an untenable place, where it was located on the first discovery of New Netherlands, for the purpose of resisting any attack of the barbarians rather than an assault of European arms, having within pistol shot, on the North and Northeasterly sides higher ground than that on which it stands, so that, notwithstanding the wall and works (muragie) are raised the highest on that side, people standing and walking on that high ground can see the soles of the feet of those on the esplanade and bastions of the fort, where the view is not obstructed by the houses and church in it and by the gabions on the wall.

"Secondly. The fort was and is encompassed only by a slight wall, two and three feet thick, backed by coarse gravel, not above ght, nine and ten feet high in some places, in others higher, according to the fall of the ground.

"Thirdly. It is for the most part crowded all around about with buildings; better adapted for a citadel than for defense against an open enemy; the houses are, in many places, higher than the walls and bastions and render these wholly exposed; most of the houses, also, have cellars not eight rods distant from the wall of the fort, in come places not two and three feet, and at one point scarce a rod from the wall, so that whoever is master of the city can readily approach, with scaling ladders from the aforesaid houses, the wall of the fort, which is unprovided with either a wet or dry ditch; and also, if need be, run a mine from the so close adjoining cellars and blow the place up. Besides this, the fort was and is without either well or cisten."

The English remained in undisturbed possession of the province, whose name was changed from New Netherland to New York, until the 13th of August, 1673, when a Dutch squadron, consisting of nineteen ships of the line, under command of Commanders Cornelis Evertsen, Jr., and Jacob Benckes, which had arrived on the 29th of July previous, during the absence of the governor. Sir Francis Lovelace, demanded the surrender of the province, which demand was acceded to by the inhabitants on the 16th of August. The name of the province was changed to New Netherland and of the city of New York to New Orange, of the fort to Fort William Hendrick.

The triumph of the Dutch was brief, for the following year peace was established between England and the States General, of Holland, by the treaty of Westminster. Under the sixth article, England regained the province of New York and maintained it until the final separation between the Colonies and the Mother Country.

January 22, [illegible] Island is [illegible] of New Netherland [illegible] been sent them [illegible] tion of the [illegible] Long Island.

The Wall [illegible]

war was apprehended with New England, were materially strengthened in 1673, after the recapture of the city by the Dutch, and upon the recommendation of Governor Colve, "houses. gardens and orchards" that obstructed the work were ordered to be removed.

By 1692, decay had weakened the foundations, and Governor Henry Sloughter in his speech, August 17th, reported "the fortifications are out of repair." The governor announced his intention of erecting a battery on the south point of the island, for the periodical war between England and France was threatened. He requested the citizens to lend him financial assistance.

The citizens declared that under their charter they had no authority to impose taxes upon the people for such a purpose. The governor saw otherwise. He put into practice the first inheritance tax known on the island. Estates were subjected to a tax of three pence on the pound, for the construction of the platform and battery. An additional tax of £233 was added for the purposes of defense, by the city, upon a mortgage of the ferry.

During the invasion of Canada, in 1689—1691, New York City suffered heavily. The citizens not only contributed their services in working upon the fortifications, but they cheerfully met every assessment that was levied upon them for the prosecution of the war. In 1693, by act of Assembly, £6,000 was ordered to be raised by tax; of this amount, £1,450 fell upon New York City. The city was also taxed for the construction of the fort at the battery the following year.

Under date of May 3, 1699, the Earl of Bellomont wrote to the Lords of Trade, and recommended the construction of good stone forts at Albany and "Schenectade," and repairing the fort at New York, which he estimated would cost £1,000. He said further: "Tis wonderful to me how Colonel Fletcher could pretend to apply the greatest part of thirty pound per cent. to the repairs of this Fort and the Governor's house, when I found everything out of repair when I superseeded him. The palisadoes of this Fort are quite decayed and the larger part of them destroyed and rotting; one of the bastions crack'd through, which will fall if not speedily rebuilt; the parapet gone to decay and must be renewed; the palisados 'tis computed will cost £600 at least to be well done and the bastion £200 and the parapet £200. The roof of the house too is out of repaire so that it rains in, and the lowest floor is decayed and rotten so that I believe the repair of the house will cost near £200 more. I must not omitt to observe to your Lordships that the old part of the house is a comfortable, convenient dwelling enough, and might have contended a Governor of a much better quality than Colonel Fletcher; and the new building will cost first and last about £5,000 New Yorke mony; so that tis plain here is so much mony consecrated to his vanity. Where all this money will be got to build and repaire Forts, I cannot tell, unless Fletcher be made to refund to the King. The Assembly here, I am almost certain, will not be brought to raise it, for I cannot prevail with 'em by any means to consent to such an additional duty as will pay the debts of the Government, which amount to upwards of £5,000."

One of the most interesting ancient military documents relating to the defenses of New York, is the report made to the Governor, the Earl of Bellomont, by Colonel W. W. Romer, whose name is perpetuated by the shoals that bear his name in New York harbor. The report is dated January 13, 1701. Colonel Romer found the distances at the Narrows between the heights on the Long Island and the Staten Island shore, to be one and one-half miles in breadth; depth of water from four to thirteen fathoms. He recommended that "there ought to be, both on Long and Staten Islands a sufficient battery with a good redoubt on each height, enclosed with proper lines of defense, communicating with the respective Batteries, and that each be furnished with 30 guns carrying 18 a 24 lbs. ball. He further recommended that a battery should be erected on Schutter's Island in the Staten Island Kills, twelve or thirteen miles from New York, to protect the town from an approach by way of Amboy. He pointed out the importance of Sandy Hook, because "reason and the Rules of War agree, that an enemy must always be kept as far off as can possibly be done, that a good blockhouse and fortification ought to be erected on the aforesaid Hook, as they would be very useful there, the channel and entrance being very narrow, and vessels on that account must pass immediately under the Hook." For these reasons he recommended "a good blockhouse and Fort of fifty guns."

"Further and lastly" he ends his report, "an enclosed battery of twelve or thirteen guns ought to be erected at the narrowest part of Hellgate, to prevent the entrance of an enemy at that point also. All this being done I am persuaded an enemy will bethink himself a hundred times before he will meditate any attack upon New York."

April, 1702, Lieutenant-Governor John Nanfan urged in his address to the Legislature, that the fortifications be "put in a good posture of defense." The following October, Lord Cornbury (Edward Hyde), then governor, in his speech, declared that the city and port of New York "was very much exposed."

It was not until 1703 when the British Colonies in North America were terror-stricken lest a French fleet should attack and conquer them, that the importance of erecting fortifications at the Narrows was realized. The war of the Spanish Succession was on. Leagued against France were England, Holland and their allies.

Governor Cornbury, in his address to the Assembly, of April 13, 1703, makes no effort to conceal his anxiety. He announced that he had received information that the French proposed to attack New York, by sea, the coming summer. "I think, he said, "the best way to prevent their design will be to erect two batteries of guns at the Narrows, one on each side, which I believe is the only way to make this port safe."

Three years later Governor Cornbury reproaches the people for their failure to erect the fortifications at the Narrows. The city, he declares, "lies very open, naked and defenseless." "I must take notice to you," he continued, "that the last Assembly (in 1703) did pass an act for the raising of £1500 towards erecting Batteries at the Narrows, which would have been of very great use at the time, had the money been collected; but it has not. I am sensible that some malicious, ill-minded people have reported that I had taken that money into my own hands. That the truth hereof may be known and justified, I recommend to you to make strict inquiry into that tax."

A suggestion of Washington's famous utterance "to be prepared for war is one of the most effectual means of preserving peace," is found in the speech which Governor William Cosby uttered to the Assembly, April 25, 1734: "The safety and protection of the Harbor of New York and of the frontiers, no time being so fit to guard against our future enemies as a time of peace; the duration of the present peace being uncertain."

The usual urgent plea was made for an appropriation—for the construction of a Battery in New York City, at the Point of Rocks (the Copsee battery, it was called), by Whitehall, and of new forts at Albany and Schenectady, reinforcing a suggestion that had been filed with the Lords of Trade, fourteen years before by Brigadier-General Hunter, who described the works at New York as "a fort of four regular bastions, fifty guns mounted, faced with stone, with neither fossee nor outworks."

The alarm consequent upon another expected rupture with France, persuaded Governor George Clarke to repeat the suggestions of his predecessors and call attention to the city's defenselessness, April 15, 1741. He requested that batteries be erected upon the wharves facing the harbor, and that one be placed at Red Hook on Long Island to prevent the enemy from landing upon Nutten (Governor's) Island.

Again, June 25, 1745, Governor Clarke suggests to the Assembly the construction of a battery of twenty guns at the east end of the town off the harbor, "and of other batteries at other points in the town, plans for which he promised later to place before them."

With a war close at hand, Governor James De Lancey reported, October, 1753, that the Copsee Battery was in a ruinous condition. The government not only would not construct new fortifications, but refused to keep in repair those that were garrisoned. All the burdens for defensive expense, such as they were, and for the times taxes were oppressive enough, fell upon the colonists. England's policy of grab and grind was exercised not alone upon her colonists in America, but upon her dependents in India. The colonists were expected to return fabulous profits to the mother country, and to submit to the most unjust regulations and laws. The more generous the colonies, the more exacting became the demands of England.

It is not necessary to enumerate the multitudinous exactions that were made upon the colonists or to dwell upon the general and loyal compliance with which all were met. Scarcely a year passed from 1700 to the outbreak of the French and Indian war that the good-natured and much-imposed-upon colonists were not called upon to honor some extra draft drawn by England, upon their patience and their purse. The province of New York contributed £5,000 toward the Braddock campaign. The following year came the long-threatened French invasion and it cost the province £45,000 to put itself in condition to properly meet the enemy. August, 1755, the news of Braddock's crushing defeat and rout struck the colonists with terror. A £10,000 tax was at once levied upon the province, which was also compelled to maintain 400 men at Crown Point. One month later £8,000 additional were raised to be contributed for Connecticut toward the expense of sending reinforcements to Crown Point. During 1757 the province of New York raised, transported and subsisted 1,000 more men for the same expidition, but the expense thus incurred was eventually borne by the home government.

The resources of the province were stretched to the limit the following year. Bills of credit were issued which aggregated £100,000, redeemable by payments of £12,000 in 1759 and of £11,000 in each succeeding year until the entire amount was liquidated. This generous contribution to the good cause—displaying a financial condition as sound as it was patriotic and loyal—justified the colonists in the conviction that New York was already a powerful factor in the aggregation of American colonies, and opened their eyes to certain possibilities that no doubt exerted an influence that can not be measured when the time came to break with the mother country.

In the meantime Lord Loudoun, with a large fleet, had arrived in New York in 1756, and, for the first time in its history, the city was put into proper condition for defense by land and by sea. A new line of defense, consisting of palisades, was thrown up across the island from river to river, not far from the line of the present Chambers street. The "upper barracks" was built north of the City Hall park, on what is now Chambers street, the colonists cheerfully submitting to a construction tax of £3,500 ; (the "lower barracks" stood on the Battery near Whitehall street, on a line with the present State street).

Upon taking possession of the city in 1776, Washington sank obstructions in the North and East rivers, and threw up fortifications to guard the narrow passages. Fort Washington was constructed near the north end of Manhattan Island, and Fort Lee on the Jersey shore opposite. Both of these were regarded as strong works. The fort at the Battery was overhauled and strengthened and a small additional battery was placed on Broadway above Bowling Green. Behind Trinity church another battery was erected on an eminence, and called McDougall's Battery, out of compliment to the patriot who constructed it. On the east side of the city two other batteries were constructed, one at the foot of Maiden lane and another at Corlear's Hook, near the present Grand street ferry.

In April, Governor's Island had been occupied by 1,000 American troops, and a couple of small batteries were hastily erected.

In Brooklyn, a line of works extended from the Wallabout, now the Navy Yard, to Red Hook. Most of the streets were barricaded and here and there in the city small works were thrown up at every vulnerable spot.

After the American army evacuated New York, the English troops constructed a number of works on the upper end of Manhattan Island, whose positions will be described later on ; the small batteries on Governor's Island were strengthened and lunettes were thrown up on the sites of the Staten Island and Long Island forts at the Narrows.

Up to the War of 1812 the States were expected to construct their own fortifications and to bear the expense, subject to whatever assistance, great or small, Congress might from time to time render. Fort Jay, on Governor's Island, was built soon after the adoption of the Federal Constitution. As far back as 1765, however, British engineers had recommended that strong works be erected on either side of the Narrows. Congress, in 1794, considered the matter of fortifying the important ports of the country. It was estimated that $12,522.36 would be necessary to construct batteries on Governor's Island and in the city of New York. Three thousand one hundred and sixty-one dollars and sixty-eight cents of this amount were to be used in fortifying Paulus Hook. At that time Fort Wood, on Bedloe's Island, had been started.

Between 1794 and 1801, Congress had appropriated $100,023.41 on the construction of Fort Jay and the smaller works on Governor's Island. It was estimated that $60,000 more would be necessary for repairs and improvements. In 1806 Fort Jay was demolished except the walled counterscarp. The construction of Fort Columbus was begun.

From the report of the Secretary of War, made by direction of the President, February 18, 1806, the following remarks are found, relative to New York harbor:

"In the year 1794 and 1795 considerable expenses were incurred in the harbor of New York, in fortifications on Governor's, Bedloe's and Ellis's Islands, and in front of the city.

"On Governor's Island, a regular enclosed work, with detached batteries for heavy cannon and mortars, was erected with a magazine and barracks, which require considerable repairs and improvements. On the other islands, there were batteries and magazines, with some barracks, which also require repairs.

"A formidable battery of heavy cannon and mortars (which is now in ruins) was erected in front of the city. A heavy park of artillery was also mounted on travelling carriages, and placed in a building belonging to the State, within the city.

"No considerable improvements have been made on the above-mentioned works, or additional fortifications erected, for the defense of the harbor of New York, within the last five years; there having been no funds for those objects furnished by the State, as contemplated by the Act of Congress of the 3rd of May, 1798, and understood to have been intended by the State.

"Engineers were employed by the Governor of the State to survey and examine the harbor, and to report the best practicable mode of defense. The report, accompanied by drawings and estimates, was transmitted to the President of the United States in the year 1801. By this project, the principal works were to be at Sandy Hook. The estimates, amounting to $3,968,658, were considered as a sufficient reason for rejecting the report; the debt of the State of New York (which was the limit of the sum anthorized to be expended) being only $1,852,035. In January, 1805, a report was also received from another engineer, accompanied by a letter from the mayor of the city, in which the Narrows were contemplated as the principal place of defense. The estimates for completing the works amounted to $2,000,000, and the plan of defense proposed inspired no confidence.

"Lieutenant-Colonel Williams, of the corps of engineers, was, last autumn, directed to make such a survey of the harbor of New York, as would enable him to report, with accuracy, the width of the Narrows, from the water's edge on each side; the distance from Governor's Island to Bedloe's, to Ellis's, and to the battery in front of the city, and from the city to the nearest point on the Jersey shore. This duty he performed, and reported, accompanying his report with a drawing of the harbor, showing the ralative situation of the several points alluded to in his instructions, with remarks on the city generally, and particularly on fortifying the Narrows."

The Secretary had this further to say:

"It will be recollected by many that in the summer of 1776 a British ship (Asia) of about forty guns had been some distance up the Hudson above New York; that it was known that she would soon pass down by that city, and the batteries were prepared at several places on the bank of the river, in and above the city, with the most sanguine expectations of destroying the ship on her passage; but, although she descended in the day time, with a moderate breeze, which afforded full time for the batteries to act on her, and a tremendous cannonade commenced from the respective batteries as she passed, no apparent injury was received by the ship; and it was generally remarked, that she appeared to be no more incommoded by the batteries than if no shot had been fired. Her distance from the batteries was about half a mile, which is little more than the distance of the center of the channel in the Narrows from any batteries which could be erected on either or both shores.

"It now remains to be decided: First. Whether the batteries or any other points, so susceptible have been so fortified as to afford a sufficient defense.to the harbor and city?

"Secondly. Whether any other practicable system of defense may be sufficiently relied upon?

"Thirdly. What general or particular system ought to be adopted?"

At every session of Congress the mode of fortifying New York was impressed with an emphasis that increased from year to year. As far back as 1806 the population, extent of resource, capital and enterprise of the city was constantly used in arguments before Congress, for appropriation for fortifications and the claim was then made that one-third of the National revenue of the capital was collected in New York City. The State had already purchased for defensive purposes the land on which the forts at Staten Island now stand. The greater part of Governor's Island also belonged to the State. During the threatening days of 1807 the Legislature of the State of New York adopted resolutions requesting "that adequate measures should be adopted by the National Government for the protection of the port of New York.

"That the agricultural as well as commercial interests of the State are deeply interested in this most desirable object.

"That in surrendering to the United States the revenue received from imposts, this State expected, and has now a right to expect, that a competent portion of that revenue would be appropriated for its defense, and that the Congress of the United States are bound by their constitutional duties, as guardians of the common defense and general welfare, to satisfy this proper and reasonable expectation."

In the report of the Secretary of War, communicated to Congress, January 6, 1809, it was stated that "the works undertaken at New York are calculated to annoy and injury any invading force which shall enter the harbor and still more one which should attempt to lie before the city. To prevent altogether the entrance of larger vessels, a line of blocks has been comtemplated, and would. as is believed, with the auxiliary means already provided, render that city safe against invading enterprise."

Fort Columbus was reported to be nearly completed, and on it fifty cannon had been mounted. Castle William was completed to the second floor, and was in shape to receive its first tier of guns which were mounted and ready to be placed. On Bedloe's Island a mortar battery covering the anchorage ground between Red Hook and Quarantine had been started, and an open barbette battery for heavy ordnance on Ellis's Island was nearly finished.

Off Hubert street, New York, 200 feet without the permanent line of the city, a battery, the North Battery, was commenced and finished that year; preparations had also been made for erecting a heavy battery on the stone foundation of the superstructure of the solid mason work at the southwest point of the city, the present Castle Garden.

December 21, 1809, Secretary of War, Eustis, reported that "Seventy-one guns were actually mounted" for the defense of New York; 150 may be actually brought into action on an emergency; and the works for the defense of the city of New York are calculated for 300 guns and 10 mortars, exclusive of those mounted on travelling carrriages, and of the works on Staten Island, erected by the State of New York, calculated for 80 guns."

Greater interest was taken in military matters during the first session of the Twelfth Congress, with the prospect of war imminent. The defenses of New York were then reported to be: Fort Columbus, mounting 60 heavy guns, brick barracks for two companies of men and officers, and a furnace for heating shot, capable pany of men and officers, 182 men.

Castle William, with 52, 42 and 32-pounders, mounted on two tiers under a bomb roof, with a terrace, capable of mounting 26 50-pound Columbiads; troops necessary, 1,014;

Bedloe's Island, mounting 24 guns, garrison, 312;

Ellis's Island, an enclosed circular battery of masonry, mounting 14 heavy guns, with barracks of stone and wood for one company of men and officers, 182 men;

On the Long Island shore of the Narrows a blockhouse was erected on the site of the present Fort Hamilton, by the first inhabitants who settled, in 1654. The work was as much of a protection against pirates and buccaneers as invaders. The English authorities for years discussed the feasibility of building a strong and permanent work at this point, but nothing ever came of it. During the War of 1812, the Americans constructed a small earthwork which they called Fort Lewis. A large fort that was to be built of granite blocks, was started at Sandy Hook, but never was finished. Work on the present Fort Hamilton on the Long Island side of the Narrows, was not begun in earnest until after the close of the second war with Great Britain.

Two interesting historical incidents are connected with this spot. The ship that brought over Colonel Richard Nicolls in 1664 dropped anchor a few yards distant from where Fort Hamilton now stands; whence the first communication to Pieter Stuyesant was dispatched, demanding the surrender of New Netherland.

One hundred and twelve year later the British Army of Invasion, under Lord Howe, landed on the site of the present Fort Hamilton.

While the General Government was consuming time in desultory discussion on the subject of fortifications, it was left to the State[*] as a matter of self preservation, to erect works of defense. New York City in 1806, bought 400 feet of ground under water off the battery on which Castle Clinton was erected (its name was changed in 1825 to Castle Garden). Provision was also made for the battery off Hubert street, and for the construction of Fort Gansevoort near the foot of the present West Thirteenth street.

During the winter of 1808 and 1809, 250 persons were given steady employment on the fortifications on the Staten Island side of the Narrows, the Legislature of New York having appropriated $100,000 for the purpose. Three works were under construction, the principal of which was Fort Tompkins. A year later report was made to the Governor that the effective water battery called Fort Richmond, at the Narrows,[†] was completed and ready for twenty-seven cannon. Two other batteries were then in process of construction, one to the east and the other to the south of this work. By the end of the year 1809, the smaller batteries were ready for platforms and guns.

As soon as war was declared, the general government made a requisition on the States of New York and New Jersey for 20,000 militia, to be concentrated in and around the city. The funds for the maintenance of these troops, however, were raised by the city of New York under promise of reimbursement on the part of the National Government. A committee of defense was promply appointed, and citizens were called upon to volunteer their services to work in the fortifications, with the result that from five hundred to a thousand men, without distinction of class, were thus occupied daily.

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[*] From the "Return of all and singular the warlike stores and property belonging to the State of New York in the Commissary of Military Stores Department," January 20, 1812, the following facts are obtained:

The State had Arsenals at the following places: New York, Albany, Plattsburg and Elizabethtown, Russell, Watertown, Rome, Onondaga, Canandaigua and Batavia. It had deposited at Fort Richmond at the Narrows, 24 32-pounders and 33 24-pounders mounted; 2 12-pound brass guns.

The State possessed 10,823 stands of arms, 8,000 flints; had deposited 48 light brass 6-pounders among the thirty-two artillery organizations, and 42 light artillery brass 3-pounders

The militia of the State, according to the "Annual inspection return for the year one thousand eight hundred and eleven" submitted on January 25, 1812, was divided into eight divisions, and aggregated 95,326 of all arms; of whom 3,385 were cavalry, 2,619 artillery, 89,322 infantry. The general return is the same as those submitted to the Legislature in 1809 and 1810.

STATE HISTORIAN.

[†] The following Words are as applicable to-day as when written in 1859, by that superb engineer officer, then Major John G. Barnard, subsequently general and chief of engineers of the United States Army, in a report which he made on "Fortifications." In view of the tremendous strides in inventing and manufacturing modern ordnance the sagacity of Gen. Barnard's utterances will strike the most indifferent laymen:

"The mere defense of the city against ordinary fleets," he wrote, "is no longer the question; but *through the defensive works to be here erected* (at the Narrows), *the nation is to measure its strength against the most lavish use of the resources of a great maritime power, aided by all that modern science and mechanical ingenuity in creating or inventing means of attack can bring against them;* in short, in fortifying New York, *we are really preparing the battlefield on which the issue of future momentous contests is to be decided.*"

STATE HISTORIAN.

Unprepared as the country itself was for war, the defenselessness of New York at the time was a matter of notoriety, not only to the inhabitants themselves, but to the enemy. It was in vain that the common council asked the Legislature to appropriate $250,000 for defensive purposes. An appel to Congress met with a similar fate. It seems ridiculous at this day to learn that the amount actually expended during the year 1812 for the defense of the metropolis, was only $11,500, and for the northern and western frontiers, $29,050. In 1813, the Comptroller's report shows that the following items had been expended: For the defense of the frontier, $15,000; purchase of arms, $37,500; expense attendant upon calling out of the militia, $12,500; and for transporting arms, $2,702.

At the same time an appropriation of $22,000 was made for a redoubt or protecting work on Signal Hill near the Narrows, Staten Island. In 1814, when the Republican party returned to power, the generosity of the State was more conspicuous; $98,500 were voted for defense and $50,000 for the sufferers on the Niagara frontier. January, 1815, it was shown that $25,500 had been contributed for defense, $205,000 for the support of families of persons who were called into the service, $50,000 for the pay of the militia and $15,000 for the sea fensibles and armorers.

In March, 1814, the city of New York was compelled to barrow $100,000 to be used in defense of the city, which equipped, manned and maintained at its own expense a large body of troops who were placed in the works. September 23, 1814, the defenses around New York were described as follows: "A strong blockhouse mounting a 24-pounder, stood at the west end of Rockaway Beach for the purpose of repelling boarding parties in small boats. A tower of solid masonry had been designed by General Joseph Swift at Hell Gate on Hallet's Point. It was called Fort Stevens. For this the government had made a partial appropriation. A small battery stood at Mill Rock at Hell Gate." The works at the Narrows were far from complete. Colonel Jonathan Williams, engineer in charge, had changed the orginal plans. He estimated that 500 men could stand out against 5,000 and that the works were capable of giving shelter and accommodation to 1,500 troops. Fort Hudson was then completed, Fort Richmond nearly so, and another battery was contemplated in the rear of both.

A line of military defenses was stretched across the island from the barrier gate at McGowan's Pass which commanded the Harlem river to the barrier gate at Manhattanville Pass which commanded the Hudson river:

"Fortifications on Benson's Point near Third avenue and One Hundred and Sixth street.

"Fort Clinton, between One Hundred and Sixth and One Hundred and Seventh streets and about one hundred and seventy yards east of Sixth avenue.

"Fort Fish, between One Hundred and Fifth and One Hundred and Sixth streets and about ten yards east of Sixth avenue.

"A stone tower about fourteen yards south of One Hundred and Ninth street and seven yards west of Seventh avenue.

"A stone tower between One Hundred and Thirteenth and One Hundred and Fourteenth streets, and between Ninth and Tenth avenues.

"A stone tower on the south side of One Hundred and Twenty-first street and about one hundred and ten yards east of Tenth avenue.

"A stone tower on the south side of One Hundred and Twenty-third street and about fifty-four yards east of Tenth avenue.

"Fort Haight, at Manhattanville Pass, about twenty yards north of One Hundred and Twenty-fourth street and one hundred and twenty yards east of Eleventh avenue.

"Along, and in the neighborhood of King's Bridge road, a number of redoubts and forts built during the Revolutionary war were still standing in 1814, between Bussing Point road—One Hundred and Forty-third and One Hundred and Forty-fourth streets, Seventh and Eighth avenues—and King's Bridge. These fortifications consisted of solid earth embankments from six to eight feet in height and were in the majority of instances exceedingly well preserved. The most conspicuous were situated as follows:

"One hundred and Forty-fifth street, One Hundred and Sixty-first street; at One Hundred and Seventy-fifth to One Hundred and Seventy-sixth the road passed sixty-seven yards east of Twelfth avenue and 900 yards east of a fort and redoubts on a point of rocks on Hudson river, thirty yards south of One Hundred and Seventy-sixth street and 200 yards west of Fourteenth avenue. At One Hundred and Eighty-third street the road ran 343 yards east of Fort Washington on Thirteenth avenue; at One Hundred and Ninety-second street 533 yards west of Fort George; at One Hundred and Ninety-sixth street 233 yards east of Fort

Tryon; at Two Hundred and Twenty-sixth street 150 yards east of Fort Prince Charles, on Tenth avenue, on the southerly side of that street."

From 1808 to 1816 the State of New York appropriated $272,000 for the fortifications on Staten Island and the defense of the port of New York.

The report of the Secretary of War, in 1818, shows that "the only work now progressing in New York is Fort Lafayette, at the Narrows upon Hendricks Reef; will mount 96 cannon, and cost $275,000; is more than half finished and can be completed in the year 1819, and will require $110,000 to be appropriated. The other positions which must by necessity be occupied to complete the defenses of New York, are: First, Sandy Hook; Second, Staten Island; Third, west end of Long Island; Fourth, Brooklyn Heights; Fifth, Frog Pond near the Sound."

AN APPARATUS FOR POINTING BY MEANS OF AN ELEVATED LINE OF METAL,* AUTOMATICALLY FINDING CONCEALED POSITION.

Presented to the Brussels International Exposition by Captain Froissart, of the Fifteenth Artillery Regiment of France.

The apparatus that I have invented renders masked fire more practicable, and thus faciltates for field artillery a development that by many people of judgment is considered necessary.

Without entering into the minute details of a precise description, such as I prepared for the inspecting committee, I wish in this outline to give an idea of my apparatus, pointing out the object I have sought and the results that I think I have obtained.

I. THE PROPOSITION.

Upon the battle fields of the future the conditions that should govern the employment of artillery will, by reason of the introduction of smokeless powder, be quite different from the conditions that have in the past controlled.

General Langlois, who a few years ago lectured at the staff school in Paris, was one of the most distinguished generals from the artillery arm, and he wrote: "It is becoming imperative that the artillery, as well as the other arms, should make use of the cover offered by the nature of the ground.

"Unfortunate would be the batteries which, in approaches and in action, could not find cover! Uufortunate would be the troops supported by such batteries!

"There must now be made in the artillery the development that was, between 1859 and 1866, made in the German infantry. Neglecting the use of cover through a spirit of false chivalry, would be a repetition of the error of the Austrian infantry before 1866, and it would lead to the same results; the artillery would be quickly paralyzed, and would become not only useless, but even baleful—it would be a millstone about the neck!"

Further, speaking of the height suitable for the observation ladder from which, in his opinion, every battery commander should direct, General Langlois writes:

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* "Line of metal" is here used as meaning the line passing through the front and the rear sights.—Tr.

"This height ought to be at least such as to prevent the enemy's seeing the flash from a gun firing smokeless powder."

And finally: "Tactical requirements demand that the artillery habitually use masked fire; the artillery must prepare for obedience to the requirements of tactics; *it can.*"

In the French Regulations of 1895, in paragraph 319, which refers to the maneuvers of batteries with horses hitched, there is on this subject the following:

"If, in view of the circumstances of battle, of the opportunities offered by the nature of the ground, and of the time that he has, the captain judge proper, he may: Halt the pieces behind a ridge that protects them from the sight of the enemy; make the drivers dismount; afterwards have the pieces brought as near as possible to the crest, all the while remaining under cover; then have the pieces moved by hand to their fighting positions. Thus will he be able to open fire before his presence has been discovered by the enemy."

Since the line of metal of a field piece in action passes through the front sight, that is to say at a maximum height of 4′ 3″ above the ground, and since the distance from the ground to the top of the heads of a great number of horses exceeds 6′ 7″, there is a minimum difference in level of 2′ 4″ to be passed over by movement by hand, for surface slopes of $\frac{1}{10}$, $\frac{1}{20}$, $\frac{1}{30}$ and $\frac{1}{40}$ this difference in level would require the pieces to be moved by hand over distances of 23′, 46′, 69′ and 92′ respectively. In the vicinity of plains, surface slopes of $\frac{1}{10}$ are rare; slopes ranging from $\frac{1}{20}$ to $\frac{1}{30}$ are usual.

Now the autumn maneuvers have demonstrated to officers who have made practical tests, that in any other than a soil as well settled as the soils of the practice grounds and of the Châlons camp, movement by hand for a distance of only 23′ is very difficult and requires considerable time.

Moreover, it is a just observation that, after all the trouble indicated in the paragraph quoted, the artillery attains, not masked fire, but half masked fire. For in order to succeed at all in moving the pieces by hand over the great dis
cated, all the cannoneers of a number of pieces sho
ployed to move each piece in that number. Now,
first pieces to their firing positions, the heads of
then the upper part of their bodies, then the t
and finally the chases of the pieces themsel
crest. From this it results that the observa
ber of targets long before the last pieces

the line, and it will be some time after this establishment before the already exhausted men, sighting by means of the usual line of metal, will be able to reply to the enemy's fire.

Paragraph 319 of the Regulations is interesting then only on account of the tendencies that it manifests; for if, as the regulations prescribe, the captain, before ordering the movement, take into consideration the nature of the ground, he must ordinarily reject this maneuver.

It is true that by using indirect fire, the captain could mask his battery; and in various parts of the French regulations there are for indirect fire rules that often give good results, when applied by instructed gunners firing at broad targets. But would it not be rash to assert that good results could be often obtained by gunners of a war personnel firing at masked targets?

If, then, paragraph 319 of the French regulations shows that the French artillery wishes to make use of masked fire, it by no means shows that it can.

Is masked fire possible to the artillery of other countries? If so, how perfect are the methods? I claim no precise knowledge as to the development of the proposition in foreign armies. However, the "*Revue d'Artillerie*" for January, 1893, announced that Germany had provided her field guns with a pointing apparatus capable of measuring azimuth angles; this apparatus is in France known as a "Goniomètre."

It is obvious that, with this apparatus, batteries established behind a ridge, could, without great difficulty, be approximately trained upon the target.

The battery commander, however, must have the means either of laying one of the pieces by direct sight, or of measuring the angle at the battery position between two lines running, one through the target, which the battery commander sees, and the other through a land mark that all the gunners see.

Without knowing how satisfactory the battery commander's goniometer has been, I may state that it is not entirely satisfactory, if it does not fulfill the requirement mentioned by General **Langlois**; that is, if its use does not prevent the flash being seen.

[illegible] has, as is shown later, numerous inconveniences. [illegible]ined to use indirect fire, the artillery took [illegible] conceal not only its personnel, but [illegible] those inconveniences [illegible] observatory that makes it practicable for the battery commander to be 15′ above the ground, that being the height above the ground of the highest point of the fiash. And on the other hand, having given the field observatory, equally essential is it that it be provided with a goniometer; for the process of pointing a piece by direct sight from the top of a ladder, involves that tedious method of approximation, since the ladder must eventually be erected in the prolongation of the line of sight. Moreover, pointing by direct sight a piece that one directs from a distance of several yards, is not closely approximate.

If the necessity for a goniometer on the observatory is granted, it is now in order to selected a goniometer. The simplest apparatus, because it requires no support other than the land, is evidently the sextant held horizontal; but this apparatus, being so easily thrown out of adjustment, cannot be expediently slung over the shoulder on the march. So we must adopt an apparatus that can be fixed in a groove at the top of the observatory; and this is not too complicated. But it is another matter to use the instrument on a ladder for the purpose of obtaining cover that will conceal the flashes. We must be able beforehand to select a point 15′ below the crest of the covering ridge; if the ladder be erected below that point, the tangent cannot be seen; if the ladder be erected above that point, the observer will be seen. There is no way of determining beforehand whether a point is the proper distance below the crest; and one succeeds in finding the proper joint only by ceaselessly moving a raised ladder, and that is a procedure that seems out of place on the battle field. Finally then, I do not think that there has heretofore been invented an observatory capable of giving masked fire that prevents the flashes being seen.

Of course the battery commander could not set up a mounted goniometer at a point 50 or 100 yards in front of the battery; for, expect in the special case of a very distant land mark, an angle measured by means of a goniometer so placed would be of no practical use to pieces so far in rear.

Independently of this unsettled question of an observatory 15′ high, let us consider indirect fire from a battery provided with goniometers and stationed at any given distance below the crest. In the first place, the battery will experience the inconveniences of indirect fire, owing to the centralization in the captain of the operations of pointing; and this centralization is necessary, for the captain alone sees the target and the points of fall, and hence he alone is able to determine the range and the direction, and to observe the error. In the second place, since the target is masked, the battery commander will generally be obliged to waste a large number of shots in determining the range. Indeed, if the enemy be concealed, there will probably be visible for ranging purposes only one or two objects, upon which it will be necessary to concentrate the shots, in order to determine the direction of the error.

Now, the degree of convergence of pieces pointed by means of goniometers, depends upon the direction of the chosen land mark and upon unknown distances from the guns to the land mark and from the guns to the target. Hence one could not, upon the ground at least, determine beforehand the correction to be made in the azimuth of each piece, in order that the direction of the error might be observed. A land mark that is directly in prolongation of the line of pieces is the only one adapted to a rapid pointing of all the pieces.

We see, then, that indirect fire aided by the use of goniometers, is when first begun, still slow and ineffectual. This slowness would be an inconvenience of but little importance, were it not for the fact that the enemy is by the flashes warned of the battery's position. Seeing the flashes, the enemy is able to reply immediately; and it is probable that, by employing progressive fire or by ranging upon the sheltering ridge, he will be able to reply effectually.

From the preceding considerations it follows that the German method of indirect masked fire by the use of the goniometer, as well as the French method of half masked fire indicated in paragraph 319 Regulations, if not a poor solution, is at best an incomplete solution of the problem proposed. This, however, should not prevent our considering the goniometer a valuable instrument for laying on a target.

In view of the difficulties indicated there are many officers desirous of advancing boldly and firing furiously, while, as in the past, crying "*Sursum Corda*!"* We doubt the probabiliy of this opinion's successfully standing the test of a day of battle. "*Sursum Corda*" should be the soldier's motto, for it is war's great resource; it should not, however, forestall precaution nor obscure tactics. If, as General Langlois has assented, "the artillery must and can use masked fire," it would be calamitous indeed, should the artillery in future not be prepared to use it as a standard fire.

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* Referenc to: "Lift up your hearts"—"We lift them.

While General Langlois was making to the technicists an appeal for methods to facilitate masked fire, I was engaged in the July field exercises of the Douai garrison. In performing my humble duties as battery commander, I was led to observe that, whenever we took the guns from the road in order to go into action in standing corn, the lines of sight for our guns were intercepted. Moreover, in the fall maneuvers I found that the movement by hand called for in our regulations could be executed only with great difficulty; the movement by hand required in rectifying the alignment after unlimbering, appeared to be the greatest that could expediently be demanded of the cannoneers.

It was difficult for me to accept the idea that the artillery had to resign itself to the impossibility of being at the same time really covered and able to point by means of a tangent sight. For in thus resigning itself, the artillery would either renounce direct fire, which I consider the only practicable fire, and accept the complications of indirect fire; or it would renounce masked fire and go with its teams to occupy the crest, horses and riders standing out against the horizon. In either case the artillery would run the risk of being decimated before it had regulated its own fire.

Accordingly, I was led to seek for the artillery the greatest protection compatible with direct fire, and I was led to seek also the means of evading the principal inconveniences of indirect fire.

For half masked fire with difficult movement by hand, it has to me appeared possible to substitute completely masked direct fire without movement by hand.

For indirect fire with so low an observatory that the flashes betray the battery, I have thought there could be advantageously substituted indirect fire with an observatory on wheels, sufficiently high to raise the eye 15′ from the ground, thus concealing the flashes.

I set to work with all the ardor that is given by a desire to perform useful work; and after a series of attempts, failures, and new beginnings, I have succeeded in devising apparatus that experiments made by me and by others better qualified, permit me to believe practicable. However, in spite of these results and in spite of the encouragement they have obtained from the Minister of War, I have not realized my hope of seeing my name attached to a reform of the pointing methods of the French artillery. Yet, there remains for me the satisfaction of telling what I have done for my branch of the service, and the satisfaction of giving an indication of its progress by exhibiting at Brussels, with authority from the Minister of War, the apparatus that I have invented.

II. THE APPARATUS.

So far I have spoken of how I was led to endeavor to improve the method of executing masked fire. I am now going to describe briefly the apparatus that I have devised, and to point out the uses that can be made of them.

The line of metal of a field piece in action is generally not more than 3′ 9″ or 4′ 3″ from the ground. In order that a piece may be aimed upon the very spot on which it is unlimbered behind a mask that prevents the drivers being seen, the line of metal must be as high as the eye of a man on horse back, *i. e.*, about 7′ 3″ from the ground.

If the battery occupies a position 7′ 3″ below the crest, it will be able to pass through the critical period of going into action without being disturbed, at least by that battery from which it is masked; here is already one real advantage. But as soon as the battery fires, it runs the risk of being discovered, for the highest point of the flash is 14′ or 15′ above the ground. If the enemy is observant, he will be able to reply soon by employing progressive fire in the direction in which he has seen the flashes. Therefore are we led to use a greater mask, if we can; but the farther below the crest the battery takes its position, the worse are the conditions for defending the approaches, and for certain slopes, the battery by taking a position far below the crest would run the risk of firing into the ridge. Hence, the battery should be established either upon the very line that gives a mask for the drivers mounted, or upon the very line that gives a mask for the flashes; it should not be established between these lines.

By such considerations I was convinced that a pointing apparatus suitable for masked fire, must be "An Apparatus for Pointing by Means of an Elevated Line of Metal, Automatically Finding Concealed Position."* That is to say, the apparatus must enable us:

1. To determine automatically upon the ground, a line that is a given distance below the crest of a covering ridge.

2. To train upon the target, by using an auxiliary line of metal, the pieces that are established upon the line determined.

This pointing apparatus may be constructed in one of two ways, accordingly as we either content ourselves with masking the drivers mounted, or resolve to conceal from the enemy the flashes of the pieces. For masking mounted drivers a line 7′ 3″ below the crest is sufficient; for concealing the flashes, the line determined must be about 15′ below the crest.

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* In the French of the inventor the name of the apparatus is: "Appareil de pointage à ligne de mire surélevée, autobathymétrique."—Tr.

For masking mounted drivers the apparatus consists of a jointed parallelogram, carrying a peep sight and a front sight; it is thus fitted for direct fire. No field observarory is necessary; the battery commander on horse back and the gunner standing upon the gun carriage, having their eyes about 7′ 3″ above the ground, can see the target, can readily determine the line to be occupied by the pieces, and can observe and point. (Fig. 1.). While performing these duties the captain and the gunner, as well as the members of the battery that bring the pieces into firing position, are masked from the enemy. Care must be taken by all not to pass the line indicated by the battery commander.

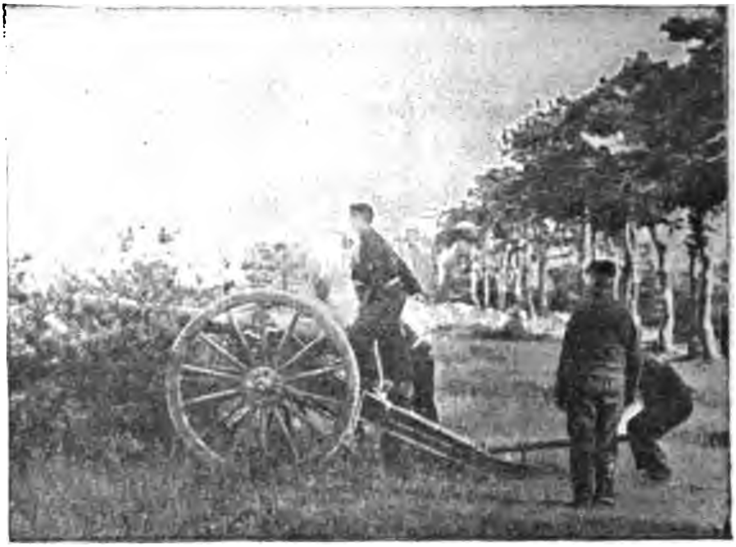

Fig. 1.

The jointed parallelogram may be made of U shaped standards (Fig. 2) the sides of which rapidly approach as they rise; these standards are firmly fastened by means of hinged brackets, to the side of the piece opposite the side on which are the ordinary front sight and rear sight. These standards, being separated by the simple rotation of a ring, are capable of folding upon the piece.

Instead of folding standards, movable bamboo standards may

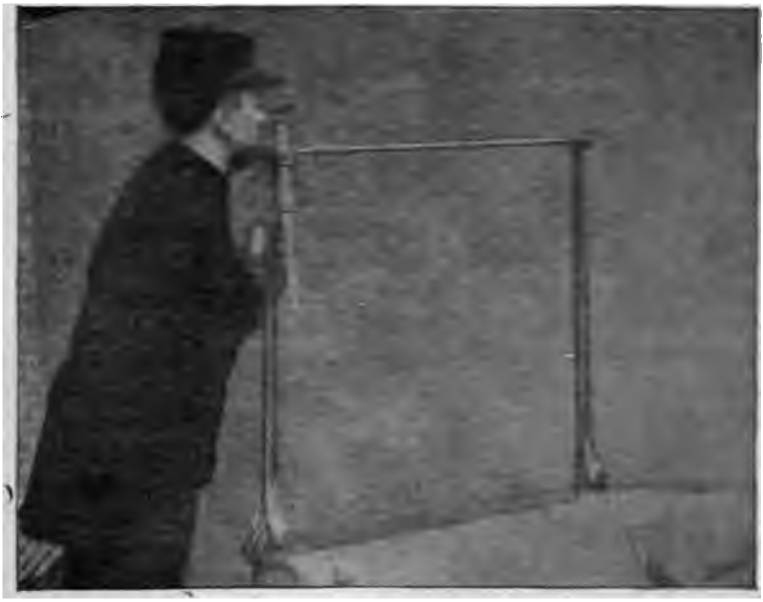

Fig. 2.

be used in the parallelogram; or, if it be desired, the gunners may be provided with sabres suitable for use as standards. In either of these cases, the standards are at the time of use inserted in oscillating sockets that are fastened to the piece by means of hinged brackets like those used with folding standards.

Whether folding or detachable, the standards support a Broca front sight and an ordinary tangent sight, and thus afford an auxiliary line of metal. The length of this auxiliary line of metal is the same as that of the ordinary line of metal. Some springs seated in the hinged brackets keep the standards perpendicular to the axis of the piece and to the axis of the trunnions; these springs serve also to take up the shock of firing and the jolts of travelling.

For masking the flashes the apparatus, called a "Battery Look-out,"* consists of an observatory mounted upon wheels and provided with a goniometer; it is particularly suitable for indirect fire, at least so long as our present gun carriages are in use.

A kind of basket resembling a balloon car and made of pliant metallic rope, is supported by two beams ten feet long; these beams may be fastened by rotating joints to the axle of any artillery carriage. This basket car supports an observer, who, either at a halt or on the march, can have himself with his sighting apparatus, raised to such height as he pleases between 7' and 15'. At command from the observer, a cannoneer seated upon the limber of the carriage that carries the observatory, raises or lowers the car by means of tackling, the fall of which winds about a windlass provided with pawl and ratchet; this windlass is fastened upon the futchel of the limber, and is within easy reach of the cannoneer.

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* "Vigie de batterie."

The observer's eye is about 7' 6" from the ground when the supports are completely raised.

At Brussels the apparatus is exhibited mounted upon an ammunition wagon; it can be, however, mounted upon a gun carriage. For I have succeeded in demonstrating that, using an elastic spring fastening, it is possible for this observatory, while raised and holding an observer, to endure the shock of recoil without the observer's being disturbed. (Fig. 3). With non-recoil carriages, such as those of the Bange and Piffard system

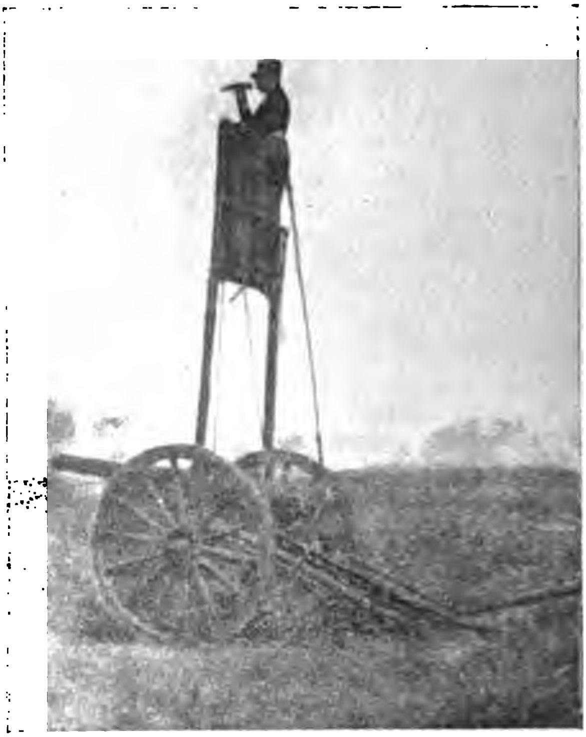

Fig. 3.

for field service (described in the "*Revue d'Artillerie*" for June, 1897), there can be no doubt of the possibility of mounting the "Battery look-out" upon the gun carriage.

The observatory supports are at present nothing but spare shafts inserted in boxes that are made on the discs of the axle shoulders. If the observatory were mounted upon a non-recoil gun carriage such support could be made of three parts so joined as to fold upon one another; in this way, when masked fire gave place to open fire, the basket car could be put under the front of the carriage like an opera hat under a chair.

The method of using the "Battery Look-out" is as follows:

When the battery is sheltered by a ridge, and when the captain wishes to fire from a position that is a determined vertical distance below the crest, the observer is raised a height equal to the determined distance, and the observatory advances toward the crest; when the observer sees the target, the observatory stands on one point of the desired firing line. One point found, the observer has simply so to direct the carriage as continually to see the target over the crest; doing this, he remains constantly on the contour that is, the required distance below the crest.

If we think of the groping necessary in using ladders, of their instability, and of the ease with which the observers are thrown from them by the least distraction, one must admit that the "Battery Look-out" presents the advantages of uninterrupted observation, and of safety for the observer; these advantages are beyond value.

The "Battery Look-out' is, on the whole, the instrument of a new branch of geodesy—the measurement of differences of level. The object of these measurements is to trace directly upon the ground contours, or lines having all points of each the same vertical distance below a crest, however irregular that crest may be.

This observatory erected behind a gun makes it possible, as General Langlois proposed, to point that gun by sight with the relative precision which that kind of pointing allows.

Not only is the observatory movable, but also can the observer move about in it; hence the observer using the "Battery Look-out" is able to place himself in the prolongation of the desired line of sight much more readily than he could from the top of a ladder. But in order not to have to move the "Battery Look-out" to a position directly in rear of each piece, both the observatory and each piece should be provided with goniometers. The observer could then measure the azimuth angle between the target and a land mark that is seen by all the gunners; and the gunners could train their pieces upon the target by using the azimuth angle gived them.

The observatory car is provided with a crude goniometer; a graduated limb that turns freely in the upper basket-hoop supports a standard about 2′ high, and this standard carries a sight. If, using this apparatus, the observer sights successively upon the tangent and upon the land mark, he determines the angle that the gunners of the pieces are to use in sighting upon the land mark in order to train upon the target; each piece is, of course, provided with a goniometer of some kind.

The limb of the observatory goniometer carries a traveller, which should at the time of the first sighting be set at the zero of the limb; thus no computation is necessary, the angle between the target and the land mark being read directly.

The dimensions of the observatory goniometer are such that an arc of about 0.04 inch measures an angle of 10′, and this angle corresponds, on a range of 2625 yards to an error of about 9 yards, or about half the interval between pieces.

For the pieces a goniometer of any model whatever range be used. I have made two kinds of goniometers for use with the guns, and I exhibit both. One of them was described in the "*Revue d'Artillerie*" for September, 1896, under the title "Appareil de pointage elliptique." That name was given because the essential feature of the apparatus is a sight that slides along a graduated ribbon that forms the two radius vectors of an ellipse. The foci of this ellipse serve as axes of rotation for two Broca sights particularly adapted for the purpose; these sights turn about the foci under the action of the two branches of the ribbon.

The second is nothing but a quadrant to which is fitted a detachable sight with graduated bar, the very accurate graduation of which may be used for measuring both horizontal and vertical angles. This instrument held horizontal is applied to the face of the piece;* some studs on the frame center the quadrant and hold it steady during the marking.

With either of those apparatus angles are measured rapidly and acurately. Though we do not avoid the slowness incident to being unable to cause the piece to converge beforehand on a chosen ranging point; yet, at least, are we able to proceed calmly, since the enemy cannot see even the flashes of the guns that are throwing projectiles upon him.

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* The quadrant held horizontal could also be supported by a circular rim of about 3″.6 (90 mm.) diameter; this rim being held perpendicular to the axis of the piece by means of a shank that fits in one of the oscillating sockets already mentioned.

It is scarcely necessary to observe that for too short ranges, or over ground of too steep a slope, firing from a position 15′ below the crest would subject us to the possibility of firing into the ridge.

The maximum slopes that allow the projectiles to pass, are $\frac{1}{12}$, $\frac{1}{10}$, $\frac{1}{7}$, respectively, for ranges of 2187 yards, 2734 pards, and 3281 yards, the slope being counted from the lowest point of the wheel to the covering point of the ridge.

The limits calculated for the trajectory of the 90^{mm} (3″.6) piece indicate that with this piece it will generally be possible to fire behind cover that conceals the flashes.

Even though only occasionally possible, a method of fire that gives the enemy no indication of the position of the battery that is firing upon him, is so tempting that one is led to try, at least, to provide the artillery with instruments that make that method practicable.

Wholly masked fire has, then, its limits; but practicable always for ordinary artillery ranges, whatever be the slope of the ground, is direct fire with the "Jointed Parallelogram."

III. USE OF THE APPARATUS IN OPEN FIELD FIRE.

Either the "Battery Look-out" or the "Jointed Parallelogram" is capable of rendering in open field fire services which, in the eyes of many officers not very favorable to masked fire, excel the services that either apparatus renders in masked fire.

The "Battery Look-out," either on the march or erected on the battle field with a tree or a house for background, enables the battery commander to extend his field of view, to survey the approaches, and to examine the nature of the ground.

The "Jointed Parallelogram" is particularly valuable for pointing, when the gunner of a piece in action finds that a bush or some high grass hides the target; for it is not possible to determine before unlimbering whether the target will be hid from the gunner, since the target is not made known to the chiet of section before unlimbering.

"Around Hay no matter what position the Foncin battery chose, it always had before it vines, shrubs, or hedges; and any one of those were sufficient in that flat country to conceal from the gunners the walls of the gardens and of the houses."* The result was that the infantry paid with its blood for the lack of equipment of the artillery.

"What is the use," asks General Langlois, "of the artillery's being so powerful, if the smallest obstruction in its front is going to destroy that power? If, before the crops are harvested, one visits the battle fields of 1870-1871, one will be convinced of this truth, viz.: If the gunner must see to point, the artillery will generally be useless."

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* General Ducrot: "La Défense de Paris."

That truth would perhaps be evident to all artillery officers of our service, if the grand maneurers were, not Fall maneuvers about Châlons camp, but July maneuvers in ordinary fields. While proclaiming that truth, General Langlois did not think that an ardent advocate of direct fire, for which in France there is great preference, would one day give gunners the material for sighting by means of a line of metal one yard higher than the ordinary line of metal.

There are those who think direct fire by means of the tangent sight preëminently the most practical fire, because it does not make each piece a passive part of a complex machine called a battery, but leaves each piece its individuality, thereby enabling it to render a good account of itself even when the battery is disorganized. Those who so think will be glad to learn that it is possible, without resorting to the apparatus of indirect fire, to relieve gunners of the difficulty against which they had to struggle when using the natural line of metal. The usefulness of the apparatus of indirect fire does not admit discussion; but do not such apparatus run the risk of being rendered temporarily useless when the ordinary line of metal is useless?

Though the artillery may not take such a position as to mask its flashes, and though it may not think of employing indirect fire, yet, obliged to go into action whenever it finds free ground, the artillery may use the Parallelogram for sighting over any vegetation that chances to be in its front. Thus, far from destroying the power of the artillery, chance obstructions become masks to protect it partially, at least, from the sight of the enemy.

Finally, while everywhere people seem to be considering as the most urgent need more rapid artillery fire, it has occurred to me that someone might set to work:

1. To increase the security of the personnel by giving the batteries the means of firing, and, if desired, of even changing their position behind a curtain which is always hung.

2. To increase, at the same time, the efficiency of the fire, for that varies directly with the composure of the personnel; moreover the efficiency of the fire will be increased by its being possible to employ direct fire.

3. To reduce the fatigue of the personnel suppressing move-

-ments by hand, which have heretofore been necessary for direct fire that was only half masked.

4. To render it difficult, by taking his target from him, for the enemy to determine the range, thus obliging him to waste in progressive fire a quantity of ammunition that may be out of all proportion to the results obtained. As a result we exhaust the enemy's ammunition as soon as possible, and that is, perhaps, the highest principle of modern tactics; from time to time are machines invented for firing more rapidly, but the means of carrying the ammunition to feed those machines are not yet found.

Each of the methods of masked fire gives some one of the advantages enumerated above; masked fire using the "Jointed Parallelogram" gives them all by allowing us "to see without being seen." The Jointed Parallelogram offers, besides, advantages that are, and that will remain, peculiar to it:

1. Greater facility in following a movable target or in changing objective.

2. Fewer lost shots and consequently greater rapidity in determining the range, for direct pointing enables us to make sure of the initial convergence of the pieces upon one ranging point.

3. Possibility of going into battery and of firing anywhere in spite of vegetation, and of using cover even in the second and third positions of the artillery.

The cavalryman remains hidden behind the ridge, and the infantryman can sight without letting anything but his cap project above the cover; is it not necessary that the battery commander and the gunner should be able to see without being seen, and to make without interference the sighting necessary for firing? This should be possible to the gunner mounted upon the gun carriage and to the captain while with his battery, to which before all else he should give his attention. I think that my apparatus gives the artillery this possibility, to which in its turn it can aspire.

My apparatus are somewhat opposed to conventionalism. My claim of fixing upon a piece in action a parallelogram, in such a way as to render it almost insensible to shock, has appeared rash to more than one of my fellow officers; however, prolonged experiments have demonstrated that it was not an empty claim, and that the resistance to shock is absolute.

On the other hand, I believe I have have proved that my "Battery Look-out" fixed upon an ammunition wagon is easily managed; and also that it has all the desired stability, since, mounted on a gun carriage and holding an observer, it has proved able to withstand the shock of discharge. I declare also that the artillery will frequently have to abandon the advantages of masked fire, and procure before all the extended fields of view.

"Masked fire," wrote General Langlois, "is adopted, not with a view to constantly seeking cover, but in order to render the artillery capable of fighting anywhere and against any objective visible to the captain."

I do not disguise the fact that my apparatus have the fault of being additional mechanism to be added to a material already too heavy and too complex. This objection, however, has been made to all the inventions that have, from time to time, been made in the modern artillery material; this objection was made to the method of loading at the breech, but nevertheless breech-loading prevailed.

It is unnecessary to point out how many operations of masked fire either condemn the artillery to showing itself, even though it submit to the intolerable movement by hand, when it wishes to employ direct fire; or condemn it to revealing its presence by the flashes, when it resigns itself to the complications of indirect fire. These inconveniences must disappear, and I have shown that they do disappear when the line of metal is raised in one case to the height of the eye of a man on horseback (7′); or in the other case to a height a little greater than that of the the highest point of the flash (15′).

I have described a "Jointed Parellelogram" that gives the artillery the means of pointing anywhere (through the narrowest opening through which a man can see the target) and that allows the batteries to employ direct fire while masked by a ridge.

I have described a "Battery Lookout" that makes the battery commander a giant at will, giving him a height of 15′; he is able to have this height not only at a halt, but also on the march; thus is the captain able to watch the approaches, and to see beyond the vanishing zone of the flashes of the battery that is masked at his feet. As a consequence the gunners obtain all the information necessary to them for effectively employing indirect fire.

The proposed measures for giving to the artillery all those great advantages, leave the artillery materiel as it is; it is sufficient to add to it a few instruments of relatively insignificant weight and volume, and of absolute simplicity.

I don't know how near is the time when our branch of the service, interrupting its hypnotic contempletion of "Rapid Fire," will recognize that a change is necessary in the method of pointing; but this I know: Whenever comes the time in which field artillery will wish to make habitual use of masked fire—in the prophetic words of General Langlois—"it can."

[Translated by J. M. Williams, First Lieutenant, First Artillery.]

PROFESSIONAL NOTES.

ARMOR AND PROJECTILES.

A New Method of Manufacturing Armor Plates.

The *Revue Industrielle* of February 12, 1898, presents a description of a new method of manufacture of armor plates, which we briefly describe in the following: The method is used by La Société Anonyme des Hauts fourneaux, Forges et Aciéries de Denain et Auzin in France, and is the invention of Jean Werth, the technical manager of the works.

The aim of the inventor is to produce a steel plate of homogenous and uniform chemical composition throughout, but which, however, will have one hard surface with a high resistance to impact, while the opposite surface is kept malleable and relatively soft. In order to obtain such results Mr. Werth takes advantage of the property possessed by certain metals, suck as nickel, cobalt or manganese, or alloys of nickel or cobalt with manganese, to impart to the steel into the composition of which it enters hardness when heated to a temperature between cherry red and bright cherry red and cooled afterward, or malleability when heated to a temperature from dull to nascent red. These phenomena are due to the direct action which these elements have on the carbon, the iron and the other chemical components of the metal. This action is of such a nature that without occasioning any change in the chemical composition of the metal it produces an allotropic transformation of its constituents. The metal becomes hard after having been heated to a cherry or bright cherry red and cooled slowly in the air, or it becomes malleable after having been heated to a dull or nascent red and cooled in the air.

The steel used is open hearth steel, free from sulphur and phosphorus. It contains from 5 to 15% of nickel or cobalt, or from 2 to 12% of manganese. By varying the relative percentage of these metals many grades of steel can be obtained, which all can easily be worked under ordinary conditions of heat. Silicon, chromium and tungsten may be present within their normal limits without in any way rendering the steel unfit for its special purpose.

The plates are made from the steel by hammering or rolling. They can be worked, drilled and in general submitted to any operation required in the manufacture of armor plates. When finished they are left to cool in the open air without danger and without any special precautions. After this they are submitted to the special process required to harden them on one side and to keep them malleable on the other side. This is done in the following manner:

The plate is placed in a cold heating furnace, and slowly and uniformly heated to a temperature either dark red or nascent red, according to requirements. Any annealing furnace where the temperature can be regulated can be used for this purpose. The dark red heat is used on plates containing the least percentage of the above quoted metallic elements, while plates with the highest percentage of the same elements are heated to a nascent red. As soon as the right temperature is obtained the plates are removed from the furnace and left to cool slowly in the open air. They are now homogeneous throughout and malleable, and can be submitted to any work to which ordinary steel with a tensile strength of from 85,000 to 110,000 pounds per square inch can be submitted.

A series of tests gave elastic limit of the metal, 70,000 to 110,000 pounds per square inch; tensile strength, 110,000 to 140,000 pounds. Bending a 4 x 1¼ inch plate around a diameter equal to twice its thickness without rupture. The metal is not brittle and can easily be bent.

After the plate is given its final shape it is ready to be submitted to the operation that impart hardness to its impact surface. On this side the plate can be hardened to any desired depth by heating it to that depth to a temperature between cherry red and bright cherry red. This heating is done slowly and uniformly, and good care is taken to keep the temperature of the rear surface at about nascent red, corresponding to 800° to 900° F. For this purpose this surface is kept cool by a circulation of water or air while the impact surface is heated. The temperature on both surfaces can be checked at any moment by the use of pyrometers, or by means of thin plates of either lead, zinc, tin, etc., whose melting points are well known, or by any other suitable means or device.

The heating of the impact side is done by building up a heating furnace in which the plates themselves constitute the walls and the bottom with their impact surface turned inward. They are exposed to the heat of the furnace, while their malleable surfaces are cooled on the outside bp means of air or water. It is most important that the heat in the furnace should not only be uniform throughout the furnace, but should be kept uniform during the whole heating operation, so that the plates will gradually be brought to a bright cherry red to any desired depth. In order to allow the heat to gradually penetrate the plate to the desired depth, the heating must be moderated from time to time during short intervals. Gas furnaces, being more easily controlled, give better results than furnaces directly heated with coal.

Instead of heating the impact surface in furnaces as here described very good results are rapidly obtained by plunging these sides of the plates into a bath of molten metal, such as lead. heated to a cherry red. This metallic bath is previously heated to the desired temperature, and after having skimmed the surface of the molten metal from all impurities the impact surface is immersed to the desired depth. During the whole operation the temperature of the metallic bath must be kept uniform, which is checked by means of a pyrometer. The malleable surface in this case also is kept below dark red in the same manner as before described. After the impact surface has been heated uniformily to a cherry red and to the desired depth the plate is removed from the metallic bath and the impact surface is left to cool gradually in the open air while the malleable side is prevented from rising above dark red. The moment the temperature of the impact surface has fallen to between dark and nascent red the more active cooling of the malleable side is stopped and the plate, raised from the ground, is left to cool slowly and uniformly. This finishes the plate as far as metallurgical operations are concerned.

Should a plate become warped during the hardening period it can be straightened again under the hammer when the temperature throughout has become uniform at a dark red heat. A curved plate is given its shape after it has been made malleable. then it is again heated up to a dark red and left to cool in the air. Then only the hardening of the impact surface [illegible] to. In the case of a curved or irregularly formed shape this hardening cannot be done in a metallic bath, but must be done by exposing the impact surface to the contact of the flame.

It is difficult to obtain from such a plate test pieces, because it is impossible to do any shop work on the hardened side.

With great difficulty it was possible to obtain such test pieces from the softer varieties of steel. In such cases the tensile strength was found to vary between 140,000 and 190,000 pounds per square inch. The metal had great resistance to shock, and yet it could be bent to an angle above 90°.

In the harder plates the impact surface resisted every attempt to work it, while the rear surface had remained perfectly malleable and could be easily submitted to any ordinary shop work.

—*The Iron Age*, March 3, 1898.

MILITARY GEOGRAPHY.

Ocean Cables in War Times.

By Alexander Porter Morse.

Eleven submarine cables traverse the Atlantic between 60° and 40° north latitude. Eleven of these connect the Canadian provinces and the United States with the territory of Great Britian: two (one American, the other Anglo-American) connect France. Of these seven are largely owned, operated or controlled by American capital, while all the others are under English control and management. There is but one direct submarine cable connecting the territory of the United States with the continent of Europe, and that is the cable owned and operated by the Compagnie Français Cables Telegraphiques, whose termini are Brest, France, and Cape Cod, on the coast of Massachusetts. All these cables between 60° and 40° north latitude, which unite the United States with Europe, except the French cable, are under American or English control, and have their termini in the territory of Great Britian or the United States. In the event of war between these countries, unless restrained by conventional act, all these cables might be cut or subjected to exclusive censorship on the part of each of the belligerent states. Across the South Atlantic there are three cables, one American and two English, whose termini are Pernambuco, Brazil, and St. Louis, Africa, and near Lisbon, Portugal, with connecting English lines to England, one directly traversing the high seas between Lisbon and English territory, and one touching at Vigo, Spain, at which point a German cable company has recently made a connection. The multiplication under English control of submarine cables has been the consistent policy of Great Britian, and to-day her cable communications connect the home government with all her colonies and with every strategic point, thus giving her exceptional advantages for commercial as well as for political purposes. The schedule blanks of rules of the English componies contain the following provisions: "The dispatches of the Imperial government shall have priority when demanded. The cable must not, at any station, employ foreigners, and the lines must not pass through any office or be subject to the control of any foreign government. In the event of war, the government (of Great Britain) may occupy all the stations on English territory or under the protection of Great Britain, and it may use the cable by means of its own employes."

It is not a pleasing reflection that in the actual situation the United States is at a great and embarrassing disadvantage. Meanwhile it would seem to be the policy of the United States to overcome this disadvantage by the multiplication of submarine cables under American or other than English competing foreign ownership and control.

Although somewhat indeterminate, the policy of the United States in respect to the landing of foreign submarine cables, so far, at least, as the executive branch of the government is concerned, appears to be based chiefly upon considerations that shall guard against consolidation or amalgamation with other cable lines, while insisting upon reciprocal accommodations for American corporations and companies in foreign territory. The authority of the executive branch of the government to grant permission is exercised only in the absence of legislation by Congress regulating the subject, and concessions of the privileges heretofore have been subject to such further action by Congress in the matter as it may at any time take. Several bills are now pending in Congress relating to the landing of foreign submarine telegraph cables within the United States, and regulating the establishment of submarine telegraphic cable lines or systems in the United States. As this article is going to press it is reported that the President has refused permission to a foreign cable company to renew a cable terminus within the territory of the United States, and that the question raised as to the power of the federal government to deny admission to the cable will be referred to the attorney-general for an opinion. Meanwhile, the executive branch of the government holds to the doctrine that, in the absence of legislation by Congress, control of the landing and operation of foreign cables rests with the President. The question of the landing of foreign cables received some consideration from the late attorney-general in connection with an injunction suit brought by the United States against certain corporations engaged in placing on the coast of New York a cable having foreign connection. And he suggested for the consideration of Congress whether it would not be wise to give authority to some executive officer to grant or withhold consent to the entry of such foreign enterprises into this country on such terms and conditions as may be fixed by law.

The principal and most important submarine cables traversing or connecting the great oceans are owned and operated by private corporations or companies. They are in number 310, and their length in nautical miles is 139,754. The length of cables owned or operated by state governments is, in nautical miles, 18,132.

The policies of states, the movements of fleets and armies, and the regulation of the markets of the commercial world, depend upon devices, communications and orders that are habitually transmitted through the agency of submarine cables. In this view, the first aim is to safeguard from wanton destruction the delicate and expensive mechanism of these cables; the second is to restrain within the narrowest limits practicable interruptions in the operation of cables, even in the midst of hostilities; and the third is to encourage the establishment and extension of submarine cables owned and operated by American capital. All these ends may be advanced by the agreement of the powers to neutralize absolutely the submarine cable systems of the world.

—*Western Electrician*, January 8, 1898.

WARSHIPS AND TORPEDO BOATS.

The English Armored Cruiser Prince George.

The *Prince George* is a first class armored cruiser, and belongs to the

Majestic class, so called from the first ship constructed on this type, comprising in all nine vessels.

The purpose of England is to be able to take the offensive and to send her warships far from her coasts and as near the enemy's shores as possible. The program of the Admirality tends more and more to realize this object. Besides, her colonies are widely scattered and far removed, not only from each other but also from the metropolis; her ships are then in time of war expected to meet the enemy and to give battle many miles from the coast.

These requirements have imposed on the Admirality the necessity of providing vessels with a very extended radius of action, consequently capable of carrying a large supply of fuel; this quality must be combined with that of speed, in order to be able to pursue an enemy and force him to fight, or to escape from a more powerful one.

These conditions are realized in a remarkable manner in the construction of the *Prince George*. Her displacement is 15,000 tons, and her speed exceeded 18 knots in the trials. Her bunkers can store 2,250 tons of coal.

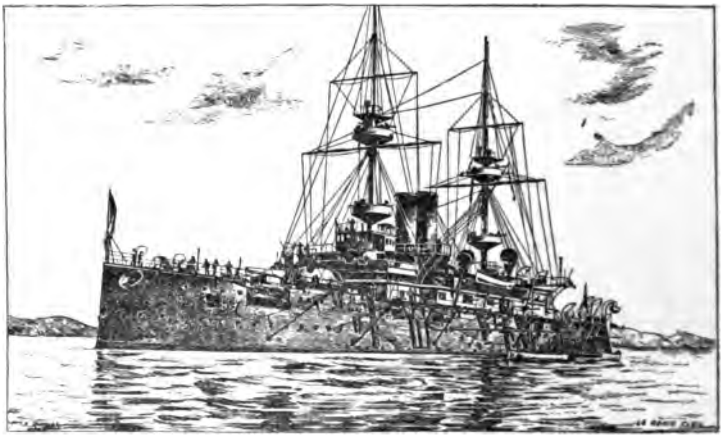

Fig. 1.

The maximum length is 425 feet; the length between perpendicular is 390 feet. Her maximum beam at the water line is 75 feet, but it decreases considerably from this point, for her sides tumble back "home" rapidly. Fullness of bilge is, moreover, one of the leading features of the ships of the *Majestic* type; it gives them a remarkable stability, the good results of which have been fully established in the case of the *Majestic* and *Magnificent*.

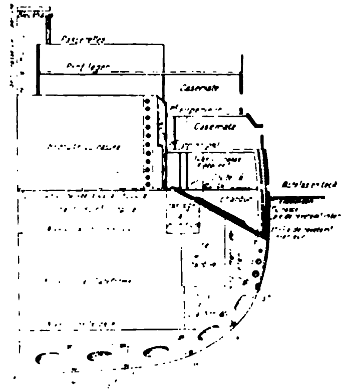

Fig. 2.

The *Prince George* has two screws each driven by a set of vertical triple-expansion engines of 6,000 horse-power each. The ship has six decks, see Fig. 2, viz.—1st, Shelter deck or boat deck; 2nd, Upper deck; 3rd Main deck or gun deck; 4th, Middle deck, at the level of the armored deck; 5th, Lower deck; 6th, Platform deck. Above these decks run foot-bridges at a height of 75 feet above the water line.

The armored deck is three inches thick. It extends over a length of 252 feet and serves to protect the engines, boilers, magazines and other vital organs. Its sides are inclined and slope downwards to meet the ship's sides at the level of the lower deck. The greatest thickness of armor in 14 inches. The two masts of the *Prince George* are each provided with two fighting tops containing each three Hotchkiss 1.5-inch guns (3-pounders Q. F.) and electric search lights.

Armament.—The main battery of the *Prince George* consists of four 12-inch guns mounted in pairs in turrets fore and aft. These guns are mounted on revolving turntables, the whole being maneuvered by hydraulic power or, in case of emergency, by hand power by means of electric motors.

They are 40 calibers long and weigh 46 tons. They are hooped their entire length. This hooping is obtained by winding on bands or ribbons of steel wire, about ¼-inch wide by .06-inch thick, forming many superposed layers. The ultimate resistance to rupture of these bands is about 90 to 110 tons per square inch of cross section. Their tension varies according to the position of the layers from 30 to 60 tons per square inch. Their total weight of wire is about 12 tons and the total length very nearly 100 miles.

The weight of the projectile of these guns is 850 pounds. The weight of the charge is 167½ pounds. The initial velocity given to the projectile is 2,400 f. s., and at 2,000 yards it can penetrate 31¼ inches of wrought iron. Each piece can be fired four times in five minutes.

The *Prince George* carries, also, twelve 6-inch Q. F. guns mounted in armored casemates, eight of which are on the main deck and four on the upper deck. These pieces are also 40 calibers long, or 249¼ inches from breech face to muzzle.

Each gun consists of a steel tube whose interior diameter is exactly 6 inches; on the rear portion of this tube is contracted a second tube of steel and round this is wound the steel wire or ribbon similar to that of the 12-inch guns, the tension varying according to the principles formulated by Mr. Longridge. Over the wire is contracted a jacket on which are cut the steel keys designed to prevent any rotation of the gun during the advance of the projectile in the bore and to cause the gun to recoil in a straight line. Contracted and screwed on the rear end is the breech-ring, from the lower side of which projects an arm attached to the piston rod of the recoil cylinder.

The breech mechanism is of the usual Armstrong Q. F. interrupted screw system. It is remarkable for its rapidity of operation.

The lighter artillery of the *Prince George* consists of: 16 Hotchkiss quick-fire guns, 12 pounders, mounted on the main and upper decks; 12 Hotchkiss 1″.5 quick-fire guns, 3 pounders, mounted by threes in each of the tops; two 12-pounder, 8 cwt. quick-fire boat and field guns; finally 8 Maxim Machine guns, .45-inch caliber, mounted on high points on the superstructure.

The torpedo armament consists of four submerged tubes, two forward and two aft, and one above water tube at the stern. Twenty-two torpedoes are carried as a supply for battle.

Engines.—As has already been mentioned, the *Prince George* is propelled by a group of two vertical triple-expansion engines of 6,000 indicated horse-power each. The high pressure cylinder is 40 inches in diameter, the intermediate 59 inches, and the low pressure 88 inches, the stroke being 4 feet, 3 inches.

The two main condensers have a total cooling surface of 13,500 square feet, and the two auxiliary condensers a total surface of 1,800 square feet. Each engine has one main air pump 18 inches in diameter. The main condensers are fed by four centrifugal pumps with impellers 3 feet 10 inches in diameter. These pumps are capable of throwing 1,200 tons of water each or 4,800 tons for all four in an hour.

Steam is furnished by eight single-ended cylindrical boilers with return tubes, having a total heating surface of 24,400 square feet, and a total grate surfaee of 820 square feet. There are four furnaces in each boiler. The steam pressure is 155 pounds per square inch.

There are 86 sets of auxiliary engines, besides the main engines, forming the complete outfit of the *Prince George*.

Electricity is supplied by three dynamos furnishing 600 amperes each, and feeding 930 incandescent lamps and six projectors.

The usual amount of coal carried is 920 tons, but the bunkers can hold a supply of more than 2,250 tons and with this amount of fuel on hand, the *Prince George* can steam for 19 days at a speed of about 15 knots without being obliged to replenish her supply.

During the four hours' trial (forced draught) the mean speed attained was 18.3 knots with a collective indicated horsepower of 12,253.

The crew, officers and sailors, numbers 758 men, but there are accommodations enough for 850 men.

—*Le Génie Civil*, October 2, 1897.

Translated by ANDREW HERO, JR., Lieutenant of Artillery.

Our Recently Purchased Warships.

It may safely be said that Armstrong's is the only shipbuilding yard in Europe where we could have purcnased two cruisers whose general features so closely approximate to the distinctive features of warship design as carried out in this country. From time immemorial American ships have been celebrated for their speed, and even more for the great power of their batteries. This was true in the days of the sailing frigate, when our ships were wont to crush their opponents with the weight of their superior gun-fire and their excellent marksmanship, and the same powerful batteries are found on the ships of our new navy. The principle is a good one. It has proved effective in the past, and it will do so in our new navy. The principle is a good one. It has proved effective in the past, and it will do so in our next naval war. The British *Magnificent* is half as large again as the *Indiana*, yet the latter carries by far the heavier battery. The British *Blake* and our own *Brooklyn* are about the same size, yet the American ship is greatly superior in the weight of its guns.

Of late years the celebrated Armstrong firm, in the North of England, has been turning out ships which have carried truly enormous batteries compared with the displacement of the ships, and, at the same time, have shown themselves phenomenally speedy. The most noted instance of this is the renowned *Esmeralda*, of the Chilean navy—not the old *Esmeralda*, of the late Chilean war, but the new cruiser of 7,000 tons displacement. This vessel carries no less than eighteen rapid-fire guns of the 8-inch and 6-inch sizes, besides eight 3-inch rapid-firers and ten 6-pounders. From these guns she could pour into an enemy from either broadside during the first few minutes of the fight an amount of shell-fire whose total energy would be far greater than that of the biggest battleship afloat.

Our new acquisitions, the *Amazonas* and *Admiral Breu*, are the very latest product of this yard, and they exhibit the characteristic qualities of good speed and abnormally heavy battery, comparing in this respect with our own *Cincinnati*. The principle dimensions, etc., of these twin ships are as follows: Length 330 feet, beam 43 feet 9 inches, draught 16 feet 10 inches, displacement 3,600 tons. They have twin screws and engines, the horse-power being 7,500 and the speed 20 knots. Their normal coal supply is 700 tons, though they have stowage room for much more, and could therefore proceed at low speed far from our coal supply stations and reach hostile waters with a supply on hand. They are protected from stem to stern by a complete Harvey steel deck which is 3 inches thick where it curves down below the water-line along the sides. This 3 inches would present a sloping surface to the enemy, which would tend to deflect the projectiles. If they were not deflected the oblique 3 inches would be equal to a vertical wall of say 5 inches of Harvey steel. Before the shells could reach this deck, however, they would have to pass through 6 or 7 feet of coal which is stored in the wings of the ship abreast the engine and boiler rooms.

The battery, as we have said, is, for the size of the ship, very powerful. It is not only powerful in numbers, but owing to the fact that its guns are of the latest Armstrong pattern, they have vastly greater power for their size than guns that were built only four or five years ago. Armstrongs are the builders of the wirewound type of gun, which has shown results greatly superior to those obtained by the built-up type. Not only are these guns more powerful for their weight, but they have improved breech mechanism which enables them to be fired with greater rapidity. The following comparison of the Armstrong ship with one of the same size and type built for the British navy from government plans shows clearly the greater fighting power of the former. The figures are taken from the official tables of the British navy and the firm in question. The speed of fire is that actually obtained by crews on board ships in commission. The *Intrepid* is one of a class of thirty ships built under the late Naval Defense Act, and though not so up-to-date as the *Amazonas*, may be considered as a good example of the average protected cruiser of the existing navies of the world.

COMPARISON OF TOTAL ENERGY OF FIRE DURING ONE MINUTE FROM EITHER BROADSIDE.

	Number and Size of Guns.	Muzzle Energy.	Shots per Minute from Each Gun.*	Total Energy.
"Amazonas," 1897	Four 6-inch.	4,840 foot tons.	6	116,160
	Two 4.7-inch.	2,158 " "	12	51,792
	Five 2.24-inch.	280 " "	20	28,000
				195,952
"Intrepid," 1892	Two 6-inch.	3,356 " "	5	33,560
	Three 4.7-inch.	1,494 " "	10	44,820
	Four 2.24-inch.	137 " "	20	10,960
				89,340

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* This rapidity of fire would not of course be maintained for any length of time in the excitement and slaughter of a modern sea fight. The figures, however, serve for the present comparison.

From this comparison then it is evident that although the two ships are of the same size, the *Amazonas* can deliver from her broadside more than double the energy of shell fire that the *Intrepid* can, although the latter ship was built only five years in advance of the former—such is the rapidity with which naval science and construction advances.

Foot-ton energy, which we have chosen as the basis of comparison, is the product of weight or mass by velocity; and as the weight of the shells for each caliber of gun is the same, the increase in energy is due to the very high velocities of the *Amazonas* guns as compared with those of the *Intrepid*. Thus the 6-inch rapid-fire Armstrong gun has a velocity of 2,642 feet per second, against 2,200 feet for the British naval gun; the Armstrong 4.7-inch gun has 2,630 feet per second, the naval gun 2,188 feet, and so on through the smaller calibers.

As further illustrating the development in naval design in a brief five years, we append a further comparison:

	Thickness of Deck.	Horse Power.	Speed.	Coal Capacity.
"Amazonas"	3 inches.	7,500	20.00	700
"Intrepid"	2 "	9,000	19.75	400

We find then that by the use of improved materials and methods the naval architect has been able, using the same capital (3,600 tons displacement), to produce a ship having superiority on every point of comparison—a ship with more speed, with 50% better protection, 80% larger coal capacity, and over 100% more powerful armament.

We can imagine no more convincing argument for a systematic and continuous program of naval shipbuilding than is presented by a study of these figures. The *Intrepid* was one of seventy-two warships which were authorized in a single appropriation and built with a rush. The present policy in England and Europe generally is to build so many ships each year, and thereby insure that each year's ships shall embody all the latest improvements. A similar policy will undoubtedly be adopted in this country, and its effect will be to bring the general average of the navy more thoroughly up to date.

BOOK REVIEWS.

Forty-six Years in the Army. By Lieutenant-General John M. Schofield. New York: The Century Co., 1897. Pp. 577. $3.00.

The work before us is a soldier's calm and dispassionate narrative of the great events transpiring under his notice, during a career that was more than usually varied and interesting. A mind naturally analytical necessarily gives corresponding color to the work it undertakes, and such is the case with General Schofield's narrative, indeed, this tendency in him to subject motives and actions to a careful analysis has given rise to serve criticism of his book, on the ground that he expresses too perfect a satisfaction with his own acts and measures. But, in our opinion, this impression results mainly from the author's method of treatment of the subject, for the *facts* are set forth with impartiality, and any one can form his own conclusions, irrespective of the author's.

Personal memoirs are always a charming form of literature, particularly when they relate to great events, or important personages, and are written by one who has had, in addition to other advantages, a good general education. General Schofield was always essentially a student, and this natural bent explains his ability to fill with credit such a variety of positions in life.

Of his Cadet studies he says:

"I devoted only a fraction of the study hours to the academic course—generally an hour, or one and a half, to each lesson. But I never intentionally neglected any of my studies. It simply seemed to me that a great part of my time could be better employed in getting the education I desired by the study of law, history, rhetoric, and general literature. Even now I think these latter studies have proved about as ureful to me as what I learned of the art and science of war; and they are essential to a good general education, no less in the army than in civil life. I have long thought it would be a great improvement in the Military Academy if a much broader course could be given to those young men who come there with the necessary preparation, while not excluding those comparatively young boys who have only elementary education."

Anecdotes of the great men who surrounded the author, as well as estimates of their characters, are a legitimate and entertaining part of his memoirs. Even in the Cadet days we find such of men like McPherson and Hood, who figured so conspicuously so near the author in the great war that was to come.

General Schofield, like General Grant, began his service in the Civil War in the West, and his name is intimately associated with the early struggle in Missouri and Arkansas, where he did heroic duty not only in the field, but also in preserving peace and controlling popular feelings, and, above all, in helping to keep these two states in the Union. Incidentally, we have here excellent character sketches of Lyon, Blair, Frémont and others. When he obtained command of the Department of the Missouri his prompt action in sending all the troops he could spare to Grant at Vicksburg gained him the confidence of both Lincoln and Grant. The party quarrel in Missouri and

Kansas, during the summer and fall of 1863, which he kept under control by the most persistent efforts, furnished an experience perhaps more remarkable and trying than that of any other officer of the regular army.

In the early part of 1864 he was assigned to the command of the Army of the Ohio and took part in the Atlanta campaign. His account of this campaign partakes somewhat of the character of a criticism of Sherman's *Memoirs*, and, while he expresses great admiration and affection for that much-loved warrior, he does not hesitate to point out defects of organization or strategy. The unwieldiness of Thomas's large army is clearly shown, and McPherson's conduct at Resaca is explained in a way very different from Sherman's:

"One half of Sherman's infantry was ample for the demonstration in front of Dalton. At least one-half should have been sent through Snake Creek Gap to strike the enemy's rear. There was no necessity to attack Resaca at all, and experience has shown what terrible losses a small force in a strongly fortified position may inflict upon a very large attecking force. Two or three brigades could have invested Resaca, with the garrison it then held, while a force large enough to hold its ground against Johnston's whole army could have been put upon the railroad between Resaca and Dalton. The result would then, in all probability, have been what Sherman expected. Indeed, the fate of Johnston's army might perhaps have been decided then and there.

"Sherman certainly cannot be suspected of wishing to do injustice to the memory of McPherson, for he respected and loved him most highly, and mourned his death with evident sincerity. But I think he is in error in saying that 'at the critical moment McPherson seems to have been a little timid.' I believe the error was Sherman's, not McPherson's."

The recital of the military movements in this campaign is enlivened by many personal anecdotes.

After the fall of Atlanta, General Schofield was ordered back to assist Thomas at Nashville. The account of the battles of Franklin and Nashville, to be understood, must be carefully studied: no mere summary would be satisfactory. General Schofield's dissatisfiaction with the slowness and inaction of Thomas appears to have been well founded, and his estimate of this great soldier of the war, so deeply beloved by all who were thrown in contact with him, so much respected by friend and foe, both as a man and a general, while it will not in all probability be satisfactory to his intimate friends and strong admirers, yet seems both fair and just.

During the early reconstruction days General Schofield was commander of the Department of North Carolina, but in the latter part of 1865 he was sent to Paris on a diplomatic mission to induce the French to withdraw from Mexico, a mission which proved entirely successful in accomplishing its immediate object and in maintaining peace and good feeling. On his return he was again busy with reconstruction, this time in Virginia, and during the impeachment trial of President Johnson he served as Secretary of War, and he laid down the war portfolio "without having incurred censure from either party."

The author's experiences as Department Commander, which involved the Canby massacre and the Modoc War, as Superintendent of the Military Academy at West Point, as Division Commander, and finally as Commander of the Army, were very various and full of interest. Though often harshly and unjustly dealt with, he was patient under his difficulties, yet firm in his assertion of the truth.

Today, when he should be enjoying the well-earned repose of retirement from active service, he is the leader of the army of reserve, which is now organizing for the national defence. J. P. W.

The History of our Navy from its orign to the present day. 1775-1897. John R. Spears. Four volumes. New York: Charles Scribner's Sons. 1897.

What could be more inspiring than the recital of the gallant deeds of our Navy in the past, what prouder title to a high position among the nations of the world, have we, what higher examples of patriotism and devotion to duty can history show? Since its origin, nearly a century and a quarter ago, it has illuminated the pages of our history with a glory that any nation may be proud of, and its past gives promise of a future that will not dim the lustre of its record.

The first American navy consisted of "eight vessels, of which two only were ships, and the others were brigs or smaller, and all were lubberly merchantmen. All told, this squadron mounted just 114 guns, of which the largest was a cannon that could throw a round cast-iron ball weighing nine pounds. Even of these there were less than fifty. And the powder to load them and the muskets with which the seamen had been armed were all borrowed from the commonwealth of Pennsylvania.

"Yet this puny squadron, 'poor and contemptible, being for the greater part no better than whale boats,' as a British authority truly says, was to go to sea to make war—against what force does the reader suppose? A navy of 112 ships, carrying 3,714 guns, of which force no less than seventy-eight ships, carrying 2,078 guns, were either already on the American coast or under orders to go there."

John Paul Jones raised the first American naval ensign on the flagship of this squadron.

Among the earliest of our naval heroes are Captain Nicholas Biddle, "one of the most heroic men known to the American naval register," Captain John Barry, Captain Lambert Wickes, "who first flaunted the American flag in British waters and took British ships within sight of the British coasts," John Paul Jones, of immortal fame, and Benedict Arnold, who, although an army officer, was given the task of preparing a flotilla on Lake Champlain to stop the invasion of Sir Guy Carleton, and when the enemy was met "no more desperate conflict is recorded in naval annals than that of Arnold that day."

From these small beginning the history carries us along through the Revolution, the War of 1812, the Civil War, to the present day, when our navy is again beginning to take its proper place, in size and importance, among the navies of the world.

The descriptions of the actions are spirited and graphic, and, by way of fairness, the account of both sides is usually given where there is a difference of opinion or in the statement of facts. The interest is varied by interspersing anecdotes of the great naval heroes, notes on the pay of the navy and life at sea in the different epochs.

As a history it is full and complete, and yet of absorbing interest. There is no mass of details to weary the mind, but every page sparkles with the fire of some soul-inspiring action. The illustrations (of which there are over four hundred), not only add greatly to the value and beauty of the work, but are in themselves a most interesting collection, many being from old prints, famous paintings, etc.

All indications point to the fact that the United States will again become a great naval power in the not far distant future. The interior of the country has been developed so rapidly of late that the nation's eyes are already turning outward for the development of her commerce, and for other fields of action. It behooves us then to study the past history of our navy in order that we may proceed intelligently in building it up in the future, and the work before us presents that history in attractive form, setting forth the lessons we ought to learn, and the mistakes we ought to avoid, in unmistakable clearness and with convincing force. J. P. W.

The Interest of America in Sea Power Present and Future. By Captain A. T. Mahan, United States Navy. Boston: Little, Brown and Company, 1897.

This volume collects in book form a series of articles originally published in the *Atlantic Monthly*, the *Forum*, the *North American Review*, and *Harper's New Monthly Magazine*. The unity of treatment is indicated in the title of the book.

These articles, although generally written with the author's clearness and charm of expression, yet differ considerably in quality. The first relates to the growing tendency of the United States to look outward, to utilize her position between the two Old Worlds and the two great oceans, and the concluding paragraph is significant as to a proper beginning for this expansion.

"In conclusion, while Great Britain is undoubtedly the most formidable of our possible enemies, both by her great navy and by the strong positions she holds near our coasts, it may be added that a cordial understanding with that country is one of the first of our external interests. Both nations doubtless, and properly, seek their own advantage; but both, also, are controlled by a sense of law and justice, drawn from the same sources, and deep-rooted in their instincts. Whatever temporary aberration may occur, a return to mutual standards of right will certainly follow. Formal alliance between the two is out of the question, but a cordial recognition of the similarity of character and ideas will give birth to sympathy, which in turn will facilitate a co-operation beneficial to both: for if sentimentality is weak, sentiment is strong."

The next article treats of the Hawaiian question in a masterly way from the standpoint of evolution, the gist of which lies in these words: "The issue cannot be dodged. Absolute inaction in such a case is a decision as truly as the most vehement action. We can now advance, but, the conditions of the world being what they are, if we do not advance we recede; for there is involved not so much a particular action as a question of principle, pregnant of great consequences in one direction or in the other."

The third essay considers the Isthmus in its relation to sea power and the fourth the author's views on a possible Anglo-American reunion. In these first papers the idea of cementing our friendship with England is dominant, and for that reason they form a group by themselxes.

The next three articles discuss the future of the United States as a sea-power, and the closing paper considers the strategic features of the Gulf of Mexico.

There is not an article in the series that is not well worth careful study by every American citizen. The author's views are based on broad principles which all thoughtful and trained men admit, and the full understanding of the subjects presented is absolutely essential to a clear comprehension of our proper policy. J. P. W.

All the World's Fighting Ships by Fred T. Dane. Boston: Little, Brown & Co. 1898. Pp. 218.

This invaluable work, containing illustrations of all the typical war-ships and torpedo-boats of the world's navies, appears most opportunely. Its aim is to supply details not usually included in other naval annals, and as the descriptive part is printed in four different languages, it has a great field of interest and usefulness. The illustrations have been made from photograph first drawing them in pen-and-ink for the sake of greater clearness in the production. No pains have been spared to insure accuracy, and the dat have in all cases been revised by experts (naval officers and ship builders) Every page is covered with illustrations, and the brief descriptions give the principal dimensions, armament, armor, speed, and other information. The system of classification and reference is simple, convenient and satisfactory. At the end of the volume is given a list of ships launched, and at present completing for sea, the coal endurance of various types, and lastly diagrams (to the same scale) showing the arrangement and thickness of the armor of every ship having vertical armor.

The author and publishers are to be congratulated on the result of their efforts, and we can only say, in conclusion that in our opinion a copy of this work should be at every sea-coast artillery post and on board every vessel in the navy.

J. P. W.

Aide-Mémoire de l'Officier de Marine. 1898. Durassier. Continué par Valentino. Paris: Henri Charles-Lavauzelle.

This well-known annual, replete with valuable information in regard not only to the French navy, but also to all the world's navies, appears once more in its usual dress, and with its contents similar to those of other years, but more complete than ever before.

Detailed descriptions of the hull, machinery, armor and armament of all modern war-ships and torpedo-boats are given in separate articles for each nation, and the data collected in tabulated form, convenient for reference and inspection.

The great interest taken in navies and war-ships at the present time, in consequence of the troubles in the East and the gathering clouds in the West Indies, causes the appearance of this annual to be looked for with more than ordinary interest. The present volume fully meets all requirements, and upholds the well-earned reputation of this standard book of reference.

J. P. W.

Der Griechisch-türkische Krieg des Jahres 1897. Nach officiallen Quellen von einem höheren Offizier. Berlin: Schall und Grund. M. 5.

This account of the recent war between Greece and Turkey, by a field or general officer in the German army, presents the first connected account that has appeared in book form, and is based on official information. The style is somewhat popular, but at the same time the operations are described with sufficient detail to satisfy the military student, and the strategical or tactical criticisms, though brief, are clear and sound.

The volume opens with an excellent account of the organization and charact of the two armies and navies, and this is followed by a description of the fi of operations, which, taken in connection with the six maps the volume, present a very satisfactory picture of the country in which the events were enacted.

After the capture of the Meluna Pass and Gritzovalli Redoubt, the account proceeds as follows:

"On the 24th of April the Turkish commander-in-chief experienced a great surprise. The subdivisions sent out to the front, instead of meeting the enemy in his strong and well-arranged position, discovered that he had withdrawn in the direction of Larissa, having vacated all his positions in the mountain. The Greeks had, indeed, retired during the night under an order from Crown Prince Constantine, and at daybreak had entirely disappeared from view. The little town of Tyrnavos was immediately occupied by the Hairi Pasha Division advancing from Damassi, and the headquarters was transferred to Kazaklar.

"The Hakki Pasha Division, advancing from Dissikato, received orders to move on Trikkala, and to occupy this important railroad point, as well as the railroad bridge over the Salambria.

"When the Turks entered Tyrnavos they saw before them a town almost entirely deserted by its inhabitants, in which, although it had been occupied for weeks by Greek troops, there were large quantities of ammunition and provisions. Of the latter, for example, crackers, sardines, wine, brandy, flour etc., were found. Edhem Pasha at once appointed a commander with instructions to post sentinels over the shops with orders to stop all plundering. In strict obedience to these orders the soldiers brought in large quantities of wine, without any Moslem of them all so much as thinking of touching any of it.

"Gradually, Greek soldiers coming out of their hiding places appeared, begging for their lives in fear and trembling, and telling how they had been persuaded that all the Greeks that fell into the hands of the victors would suffer death. They were quieted and fed, and then set free. In the very best of order and system the sentinel and patrol service was then instituted and conducted; and the churches were treated with particular consideration and respect."

The same order and discipline marked the occupation of the other towns by the Turks.

The entire campaign in Thessaly is set forth with equal simplicity of language and clearness of description. Everywhere the poor character of the Greeks, as soldiers and sailors, is in evidence: in Thessaly, in Epirus and in the operations at sea. Everywhere the Turks showed and proved themselves capable of conducting an offensive campaign, with the same energy and devotion to duty which they were known to possess in a defensive campaign.

This comparatively brief account of a short campaign is well worth studying, not so much for the lessons in strategy and tactics which it teaches, as for the more general lessons in preparedness, training and discipline.

J. P. W.

Kriegsgeschichtliche Beispiele aus dem deutsch-französischen Kriege von 1870 71. Von Kunz, Major a. D. Heft 5. Berlin: E. S. Mittler und Sohn. 1897. Mark 2.

The fifth number of this instructive series of historical incidents from the Franco-German war of 1870-71 treats of French cavalry attacks on German infantry and artillery. Eighteen separate actions are described, the most important being the great cavalry attacks at Sedan. The great number of these attacks and the almost uniform results make the conclusions particularly valuable. With the exception of gaining a little valuable time, not one of them had the slightest effect on the general course of the events transpiring. The German infantry resisted successfully every French cavalry attack, not only when the former was victorious, but even when its tactical units were broken up, and there was hardly a single officer left unwounded in the firing line.

These attacks were all frontal, in a single line or in a succession of lines, the French cavalry never succeeding in gaining the flanks of the German infantry.

The conclusions to be drawn from the experiences here cited may be summed up as follows:

1. A frontal attack by cavalry against unshaken infantry can be justified only when the gaining of a little time is absolutely necessary in order to save a defeated army. Any other result is not to be expected, indeed, is practically excluded.

2. An attack on the flanks of unshaken infantry promises greater success than a frontal attack in line or in echelons. With the generally adopted deep formation of the infantry of today, however, even such a flank attack can have but a passing effect, and must end with the almost complete annihilation of the attacking cavalry.

3. When the enemy is beaten, with heavy losses, then strikes the hour for the victor's cavalry,—this is its true field of glory.

This number forms a valuable addition to the series, and treats the subject it discusses in the same thorough manner as the other subjects are treated in preceding numbers.

J. P. W.

Preparatory Battle Formations. By Major-General H. Bengough, C. B. London and Aldershot: Gale and Polden, Ltd. One Shilling.

The French have lately laid great stress on small columns in those portions of the line of battle not directly under infantry fire, and this idea has been adopted by the English.

The pamplet before us is a development of this idea, the principle being to to form in section columns at extended order interval, and the advantages claimed are great elasticity, facility of forming to the front rapidly, or showing a front to a flank, power to change direction of advance readily, offering a difficult target to artillery, and affording facilities for the passage of our own cavalry and artillery.

The proposed system deserves careful study: Major-General Bengouch is a practical soldier, firm in his conviction, and fearless in the expression of his views, yet based on sound principles.

J. P. W.

BOOK NOTICES.

[These books will be fully [illegible] as space becomes available.]

Die Heere und Flotten der Gegenw[illegible] Erster Band: Deutschland Berlin: Schall und Grund. Mark 15.

Die Lehre vom Schuss und Schuss [illegible] Berlin: E. S. Mittler und Sohn. 189[illegible]

Condiciones que debe llenar el Material de Artilleria de Campaña. D. José de Lossada y Canterac. Madrid: Memorial de Artilleria. 1898.

Petit Dictionnaire Militare, par W. Stavenhagen. Premierè Partie: Français-Allemand. Berlin: Librairie Militaire de R. Eisenschmidt. 1897. Mark 5.50.

INDEX TO CURRENT ARTILLERY LITERATURE.

PERIODICALS CITED.

Abbreviations employed in index are added here in brackets.

All the periodicals are preserved in the Artillery School Library, Fort Monroe, Virginia.

ENGLAND.

Aldershot Military Society. *Occasional.*
Aldershot. Copies 6*d each.*

Arms and Explosives. [*Arms and Ex.*] *Monthly.*
Effingham House, Arundel Street, Strand, London, W. C. Per year 7*s.*

Army and Navy Gazette. [*A. and N. Gaz.*] *Weekly.*
3 *York Street, Covent Garden, London. Per year* £1 12*s* 6*d.*

Canadian Military Gazette. [*Can. Gaz.*] *Fortnightly.*
Box 2179 *Montreal, Canada. Per year* $2.00.

The Engineer. [*Eng.*] *Weekly.*
33 *Norfolk Street, Strand, London. Per year* £2 6*d.*

Engineering. [*Eng'ing.*] *Weekly.*
35-36 *Bedford Street, Strand, London, W. C. Per year* £2 6*d.*

Journal of the Royal United Service Institution. [*Jour. R. U.S.I.*] *Monthly.*
17 *Great George Street, London, S. W. Per year* 24 *s.*

Journal of the United Service Institution of India. [*Jour. U. S. I. India*] *Quarterly.*
Simla, India. Per year $2.50.

Photographic Journal. [*Photo. Jour.*] *Monthly.*
12 *Hanover Square, London.*

Proceedings of the Institution of Civil Engineers. [*Proceedings I. C. E.*]
25 *Great George Street, Westminister, London.*

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[*Proceedings I. M. E.*] 19 *Victoria Street, Westminister, London.*

Proceedings of the Royal Artillery Institution. [*Proceedings R. A. I.*] *Monthly.*
Woolwich, England.

Professional Papers of the Corps of Royal Engineers.
[*Prof. Papers Corps Royal Eng'rs.*]
Chatham, England.

Review of Reviews. [*Rev. of Rev. Austral.*] *Monthly.*
169 *Queen Street, Melbourne, Australia. Per year* 11 s. 6d.

Transactions of the Canadian Institute. [*Trans. Canadian Inst.*]
58 *Richmond Street, Toronto, Canada.*

Transactions of the Canadian Society of Civil Engineers.
[*Trans. Canadian Soc. C. E.*]
Montreal, Canada.

Transactions of the East of Scotland Tactical Society.
[*Trans. E. of S. Tactical Soc.*]
51 *Hanover Street, Edinburgh, Scotland.*

Transactions of the Institute of Naval Architects.
[*Trans. Inst. Naval Architects.*]
5 *Adelphi Terrace, London, W.C.*

United Service Gazette. [*U. S. Gaz.*] *Weekly.*
4-6 *Catherine Street, Strand, London, W. C.* *Per year* £1 10*s* 6*d.*

FRANCE.

L'Avenir Militaire. [*Avenir.*] *Semi-weekly.*
13 *Quai Voltaire, Paris.* *Per year* 18 *Fr.*

Le Génie Civil. [*Génie C.*] *Weekly.*
6 *Rue de la Chaussée d'Antin, Paris.* *Per year* 45 *Fr.*

Journal des Sciences Militaires. [*Sciences Militaires.*] *Monthly.*
Rue et Passage Dauphine 30, *Paris.* *Per year* 40 *Fr.*

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23 *Rue Madame, Paris.* *Per year* 30 *Fr.*

Mémoires et Compte Rendu des Travaux de la Société des Ingénieurs Civils.
[*Ingénieurs Civils.*] *Monthly.*
10 *Cité Rougemont, Paris.* *Per year* 36 *Fr.*

Mémorial des Poudres et Salpêtres. [*M. Poudres et S.*] *Quarterly.*
Quai des Grands-Augustins, 55, *Paris.* *Per year* 12 *Fr.*

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76 *Rue de Seine, Paris.* *Per year* 6 *Fr.*

Revue d'Artillerie. [*R. Artillerie.*] *Monthly.*
5 *Rue des Beaux-Arts, Paris.* *Per year* 22 *Fr.*

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Berger Levrault et Cie, Rue des Beaux-Arts 5, *Paris.* *Per year* 33 *Fr.*

Revue du Cercle Militaire. [*Cercle.*] *Weekly.*
37 *Rue de Bellechasse, Paris.* *Per year* 27 *Fr.*

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8 *Rue Saint-Dominique, Paris.* *Per year* 27 *Fr.*

Revue d'Infanterie. [*R. Inf.*] *Monthly.*
11 *Place Saint André-des-Arts, Paris.* *Per year* 25 *Fr.*

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11 *Place Saint André-des-Arts, Paris.* *Per year* 25 *Fr.*

Le Yacht—Journal de la Marine. [*Yacht.*] *Weekly.*
55 *Rue de Chateaudun, Paris.* *Per year* 30 *Fr.*

GERMANY.

Allgemeine Militaer-Zeitung. [*A. M.-Zeitung.*] *Semi-weekly.*
Darmstadt. *Per year* 24 *M.*

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Koch Strasse, 68-78, *Berlin, S. W.* 12. *Per year* 12 *M.*

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Koch Strasse, 68, *S. W.*, *Berlin.*

Deutsche Heeres-Zeitung. [*Heeres-Zeit.*] *Semi-weekly.*
Wilhelmstrasse 15, *Berlin.* *Per year* $6.00.

Internationale Revue. [*Int. Revue.*] *Monthly.*
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Kriegswaffen. [*Kriegswaffen.*] *Monthly.*
Rathenow, Germany. *Per year* $4.50.

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Militaer-Wochenblatt. [*Wochenblatt.*] *Semi-weekly.*
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Militärische Rundschau. [*Mil. Rundschau.*] *Occasional.*
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Schadenplatz 14, *Düsseldorf.* *Per year* $5.00.

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AUSTRIA.

Mittheilungen ueber Gegenstaende des Artillerie und Genie-Wesens. [*Mitth. Art. u. G.*] *Monthly.*
Wien, VI, Getreidemarkt 9. *Per year* 1 *Fl.* 50 *Kr.*

Mittheilungen aus dem Gebiete des Seewesens. [*Seewesens.*] *Monthly.*
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I. Eschenbachgasse, No. 9, *Wien.* *Per year* 10 *Fl.*

SWITZERLAND AND BELGIUM.

Allgemeine Schweizerische Militaer-Zeitung. [*A.S.M. Zeitung.*] *Weekly*
Basel, Switzerland. *Per year*, 8 *Fr.*

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Rue St. Georges 32, *Ixelles, Belgium.* *Per year* 12.50 *Fr.*

Monatschrift fuer Offiziere Aller Waffen. [*Monatschr.*] *Monthly.*
Frauenfeld, Switzerland. *Per year* 5 *Fr., plus postage.*

Revue de l'Armée Belge. [*A. Belge.*] *Bi-monthly.*
22 *Rue des Guillemins, Liège, Belgium.* *Per year* 13 *Fr.*

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Boletin del Centro Naval. [*Boletin.*] *Monthly.*
438 *Alsina, Buenos Aires, Argentina Republica. Per year* $11.00.

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258 *Calle Montevideo, Buenos Aires, Argentina. Per year* 10 $\$\frac{m}{n}$.

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5 *Calle de Cervantes, Barcelona, Spain. Per year* 32 *Fr.*

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Bi-monthly. Praça da Republica N. 32, *Rio de Janeiro, Brazil.*

Revista de Engenheria Militar. [*Engenheria Mil.*] *Monthly.*
27 *Rua Nova do Almada, Lisbon, Portugal. Per year* 1 $ 800 *réis.*

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56 *Calle de Alcalá, Madrid, Spain. Price U. S.* $4.45.

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Revista Militar. [*R. Mil. Portugal.*] *Semi-monthly.*
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Revista Militar. [*R. Mil. Chile.*] *Monthly.*
Santiago, Chili.

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Artillerie-Tidskrift. [*Art. Tids.*] *Bi-monthly.*
Stockholm, Sweden. Per year, U. S., $1.75.

De Militaert Gids. [*M. Gids.*] *Bi-monthly.*
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Copenhagen, Denmark. Per year, U. S., $2.50.

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Rivista di Artiglieria é Genio. [*R. Artig.*] *Monthly.*
Tipografia Voghera Enrico, Rome. Per year 30 *L.*

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Rome. Per year 25 *L.*

UNITED STATES.

American Engineer and Railroad Journal. [*Eng. and Rail. Jour.*] *Monthly.*
140 *Nassau Street, New York City. Per year* $2.00.

American Journal of Mathematics. [*Jour. Math.*]
John Hopkins University, Baltimore, Md.

American Machinist. [*Amer. Mach.*] *Weekly.*
256 *Broadway, New York City. Per year* $3.00.

American Manufacturer and Iron World. [*Man. and Iron World.*] *Weekly.*
59 *Ninth Street, Pittsburgh, Pa. Per year* $4.00.

Annual of the Office of Naval Intelligence. [*Naval Intelligence.*]
Washington, D. C.

Army and Navy Journal. [*A. and N. J.*] *Weekly.*
New York City. Per year $6.00.

Army and Navy Register. [*A. and N. R.*] *Weekly.*
Washington, D. C. Per year $3.00.

Bulletin of the American Mathematical Society. [*Bulletin Math. Soc.*]
University Heights, New York City.

Cassier's Magazine. [*Cas. Mag.*] *Monthly.*
World Building, New York City. Per year $3.00.

Digest of Physical Tests. [*Digest.*] *Quarterly.*
1424 *N.* 9*th Street, Philadelphia. Per year* $1.00.

Electrical Engineer. [*Elec. Eng.*] *Weekly.*
203 *Broadway, New York City. Per year* $3.00.

Electrical Engineering. [*Elec. Eng'ing.*] *Semi-Monthly.*
443 *The Rookery, Chicago, Ill. Per year* $1.00.

Electrical Review. [*Elec. Rev. N. Y.*] *Weekly.*
41 *Park Row, New York City. Per Year* $3.00.

The Engineer. [*Eng. N. Y.*] *Fortnightly.*
106-108 *Fulton Street, New York City. Per year* $2.50.

Engineering Magazine. [*Eng'ing. Mag.*] *Monthly.*
120-122 *Liberty Street, New York City. Per year* $3.00.

Engineering News and American Railroad Journal.
[*Eng'ing News and R.R. Jour.*] *Weekly.*
220 *Broadway, New York City. Per year* $5.00.

Engineering and Mining Journal. [*Eng. and Min. Jour.*] *Weekly.*
253 *Broadway, New York City. Per year* $5.00.

The Iron Age. [*Iron Age.*] *Weekly.*
96-102 *Reade Street, New York City.* ***Per year*** **$4.50.**

Journal of Electricity. [*Jour. Elec.*] *Monthly.*
421 *Market Street, San Francisco, Cal.*

Journal of the American Chemical Society. [*J. Chem. S.*] ***Monthly.***
Easton, Pa. Per year $5.00.

Journal American Society of Naval Engineers. [*A.S.N. Egrs.*] ***Quarterly.***
Navy Department, Washington, D. C.

Journal of the Association of Engineering Societies. [*Eng. Soc.*] ***Monthly***
257 *South Fourth Street, Philadelphia. Per year* $3.00.

Journal of the Franklin Institute. [*Frank. Inst.*] *Monthly.*
Philadelphia, Pa., Per year $5.00.

Journal of the Military Service Institution. [*Jour. M. S. I,*] ***Bi-monthly.***
Governor's Island, New York City. Per year $4.00.

Journal of the U.S. Cavalry Association. [*Jour. U. S. Cavalry*] ***Quarterly.***
Fort Leavenworth, Kansas.

Journal of the Western Society of Engineers. [*W. Soc. Eng.*] ***Bi-monthly.***
1737 *Monadnock Block, Chicago, Illinois. Per year* $2.00.

Marine Review. [*Mar. Rev.*] *Weekly.*
Cleveland, Ohio. Per year $2.00.

Military Information Division. [*Mil. Information Div.*] *Occasional.*
War Department, Washington, D. C.

Notes on Naval Progress. [*Naval Intelligence.*] *Occasional.*
Navy Department, Washington, D. C.

Pennsylvania Magazine of History and Biography. [*Penn. Mag. of Hist.*]
Quarterly.
13 *Locust Street, Philadelphia. Per year* $3.00.

The Photographic Times. [*Phot. Times.*] *Weekly.*
60 *and* 62 *E.* 11*th Street, New York City. Per year* **$5.00.**

Physical Review. [*Phys. Rev.*] *Bi-monthly.*
Cornell University, Ithaca, New York. ***Per year*** **$3.00.**

Popular Science Monthly. [*Pop. Sc. Mo.*] *Monthly.*
72 *Fifth Avenue, New York City. Per year* $5.00.

Proceedings of the American Philosophical Society.
[*Proceedings of A. Phil. Soc.*]
104 *South Fifth Street, Philadelphia, Pa.*

Proceedings of the U. S. Naval Institute. [*Naval Inst.*] ***Quarterly.***
Annapolis, Md. Per year $3.50.

Public Opinion. [*Pub. Opin.*] *Weekly.*
New York City. Per year $2.50.

Review of Reviews. *Monthly.*
13 *Astor Place, New York City.* ***Per year*** **$2.50.**

The Scientific American. [*Scien. Amer.*] *Weekly.*
361 *Broadway, New York City. Per year* **$3.00.**

Shooting and Fishing. *Weekly.*
293 *Broadway, New York City. Per year* **$3.50.**

Technology Quarterly. [*Tech. Quart.*] *Quarterly.*
Mass. Inst. of Tech., Boston, Mass. Per year, $3.00.

Transactions American Institute of Electrical Engineers.
[*Inst. Elec. Eng'rs.*] *Monthly.*
26 *Cortlandt Street, New York City. Per year* $5.00.

Transactions American Institute of Mining Engineers.
[*Trans. Inst. Min. Eng'rs.*]
P. O. Box 225, *New York City.*

Transactions of the American Society of Civil Engineers.
[*Trans. A. S. Civil Eng'rs*]
127 *East* 23*d Street, New York City.*

Transactions of the American Society of Mechanical Engineers.
[*Trans. A. S. Mech. Eng'rs.*]
12 *West* 31*st Street, New York City.*

Transactions of the Society of Naval Architects and Marine Engineers.
[*Naval Architects and Marine Eng'rs.*]
12 *West* 31*st Street, New York City.*

Western Electrician. [*West. Elec.*] *Weekly.*
510 *Marquette Building, Chicago, Illinois. Per year* $3.00.

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1898.

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MOVING TARGETS IN USE IN THE LIGHT ARTILLERY OF ENGLAND, GERMANY, FRANCE, ITALY, AND SOME FORMS RECENTLY TRIED BY THE LIGHT ARTILLERY BATTALION AT FORT RILEY, KANSAS.

In a pamphlet entitled "Instruction for Practice, horse, field and Mountain Artillery 1896," four styles of moving targets and two of surprise targets are described for use in the English service.

Target "A" consist of a half tun vat or other cask rolling between two pieces of timber or shafts about 20 feet long carrying a flag eight feet high and a rectangular target in front about three by four feet in size. (See sketch "A").

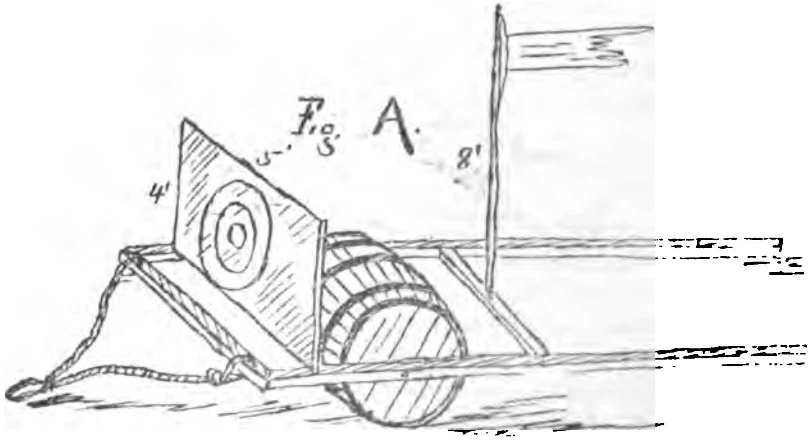
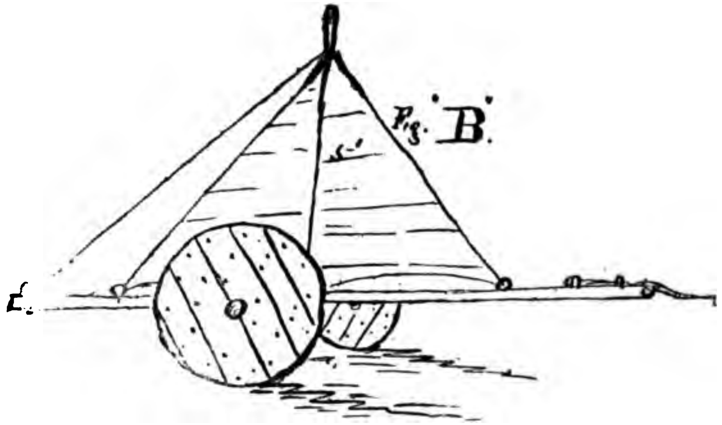


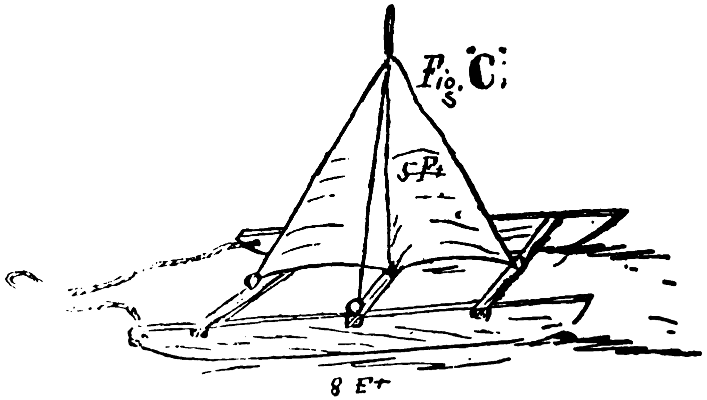
Fig. A.

Target "B" consists of a two-wheeled truck, 6 foot axle, wheels 3 feet 6 inches in diameter, (board) tongue ten or eleven feet long to which a tow line is attached.

The frame-work carries a triangular canvas target 5 feet high and five feet base. This target is recommended for smooth sandy ground. (See sketch "B").



Target "C" is similar to target "B" except that it is mounted on two board runners 8 feet long and 1 foot high. The tow line for these targets "A," "B," "C" is a 2 inch rocket or coir line. (See sketch "C").



Target "D," Colonel Richardson's pattern, consists of a frame platform 13 feet wide and 10 feet long made on 4 two by four pieces. Between the front ends of the two inside pieces is placed a cask about 4 feet long and 2 feet 6 inches in diameter revolving on an axis so that it will act as a roller. The rear part of the frame drags on the ground. This platform carries a vertical frame 7 feet high and 13 feet wide of light slats on which are tacked 4 cavalry or 5 infantry silhouettes. The tow-line used is a

3 strand 2½" tarred hawser 500 fathoms long. According to the English firing regulations practice will be carried on only—

1. When the target is advancing directly toward the battery.
2. When advancing obliquely.
3. When crossing the front.

No practice is allowed when retiring either directly or obliquely on account of risk of ricochet.

A picket and snatch block is used in the advancing target to change the direction of the cable and the team goes off to either flank. If the picket and block is 600 yards in front of the battery the team should be 400 yards to flank at starting, 600 yards being within danger space of common shell bursting in muzzle. The tow line may be run directly through the battery, horses moving to the rear, in which case the target can advance right up to the battery.

From just outside "case" range (400 to 500 yards) to the end of the run, the battery, the pace, should, if practicable, be the gallop.

When moving diagonally (45°) across the line of fire no more than 500 yards of tow line is used and no stakes or blocks are necessary, making the pull direct.

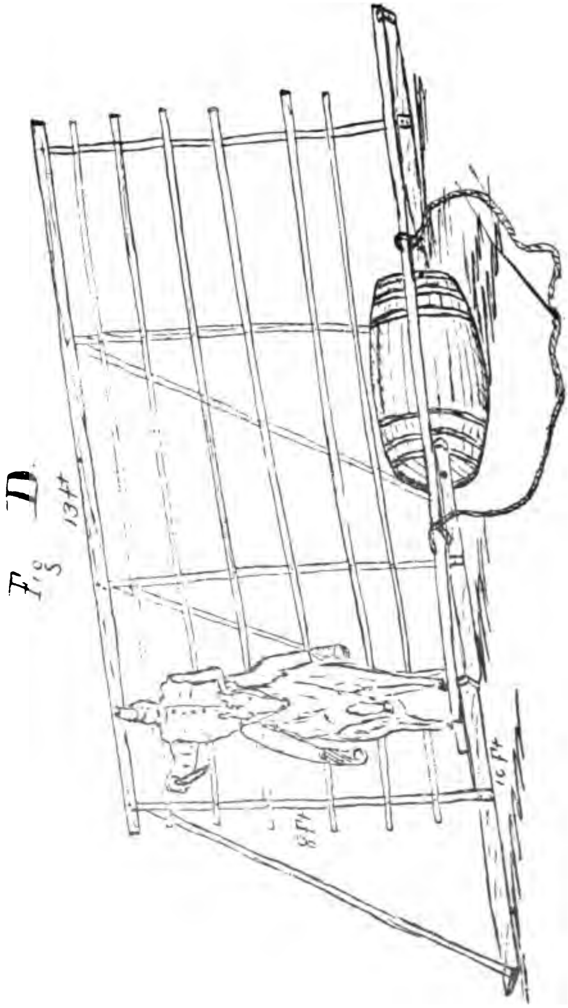
Case 3, moving directly across the front of the battery, is considered the least instructive, the range varying so little; 350 yards of tow line is used between team and this target.

The pace of the moving target may be doubled by hooking in to a single block the standing end being made fast to a picket. (See sketch "D").

Two styles of surprise or disappearing targets are described. "E": On the usual bell crank method, the figures being raised from the prone position to the vertical, by pulling a rope to the flank and falling back again when the pull is released, the friction of the rope being overcome by the sand bag, "A." "F" is a vertical frame of silhouettes on a central post working in a heavy wheel placed horizontally on the ground by means of a rope rigged off to either flank; this may be swung facing the firing point or virtually disappear by being swung back 90° or end on the battery. (See sketches "E" and "F").

Any number of these separate targets can be arranged in a group and operated by one line. (See sketch "G").

In a pamphlet entitled—"Istruzione sul Tiro per L'Artiglieria da campagna, a cavallo, e da Montagna, 1883 (Instruction for Target Firing for Field, Horse and Mountain Artillery), the Italian target used and described is simple and strong and con-



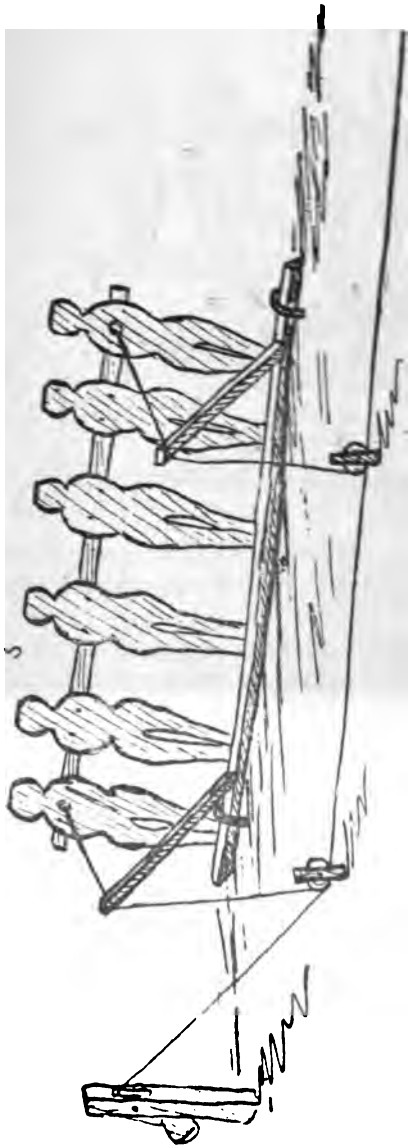
sists of two parallel wooden runners on which screens are mounted representing infantry, cavalry, etc. These screens are hinged at the bottom and lie horizontally when target is at rest, being pulled into the vertical position when a strain is put on the cable. The screen can be placed on the runners at any angle to the line of march of the target and thus be kept normal to the line of fire. The tow line used is rope. (See sketch "H").

In a publication entitled "Instruction for Target Practice, Horse and Field for the German army, [illegible] the following targets were described :

The German [illegible] moving targets are many in form but are [illegible] crank and hinge principle, alone or in groups, the [illegible] representing infantry, cavalry and artillery.

The [illegible] are all mounted on runners about 3 yards [illegible]. The targets are hinged and some [illegible] represent one thing, and when [illegible] put in motion, another object.

[illegible] A piece of artillery in action, at rest ; and when [illegible] moving, a piece limbered up.



A.

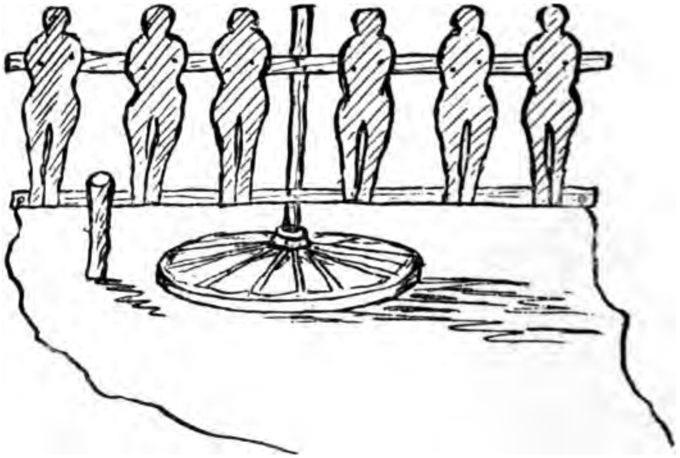
Or—infantry lying down, then infantry standing and moving to the front. (See sketch "J").

The tow line used by the Germans is a wire cable 5 strands for 2 mm. diameter, also a 4 strand steel wire cable 1¼ mm. in diameter, strength 1500 lbs. Two of the forms of disappearing targets, bell crank system, are shown in Figs. "M" and "N"; "N" target being behind a parapet. A

When it is desired that the target stop at a certain definite point, a short piece of rope is put in between the end of the wire and the target, of less strength than the cable; the cable is led between two stout stakes driven into the ground at the desired point, and when the target strikes the stakes, the rope, being weaker, breaks; and the target, of course, stands fast, changing its character or disappearing according to its construction. (See "L"). The cable is carried on reels on a limber and when broken is spliced after the following method, nds are bent back on themselves for an inch or so, lapped t 3 inches [illegible] and closely wrapped with third piece of wire, Fig. "K", the [illegible] making a joint that will easily run through ck.

a publication [illegible] "Instruction sur la formation de

Fig. "F"



pointeurs dans les corps de troupe de L'Artillerie 1888" and in the "*Revue d'Artillerie* June, 1891," French targets and practice are described.

The French assert that the necessity of the employment of moving targets for artillery is universally recognized, but on account of the numerous difficulties they have found in their construction and successful manipulation they state the inventive genius and originality of officers should constantly be exercised to better the apparatus.

The two greatest difficulties they find are in the breaking of the cable, either by excessive strain or by fragments of shell. The cable used was rope.

Two forms of targets are described, one a moving target and the other a disappearing target.

The moving target is constructed as follows: Two limbers with an upright post 8 feet high attached to each with a pulley at the top, are placed 55 yards apart.

Between these posts and suspended from a light wire grill is the target which consists of 25 pieces of cloth 18 inches wide and 4 or 5 feet long suspended from the grill 18 inches apart. The grill is kept taut by a rope fastened to either end and passing through the pulleys at the top of the upright to a heavy iron ball dragging behind each limber on the ground.

To the pole of each limber is attached a separate cable leading parallel to the line of fire, for about 600 yards, or for the distance desired to move the target; then each cable is taken around a

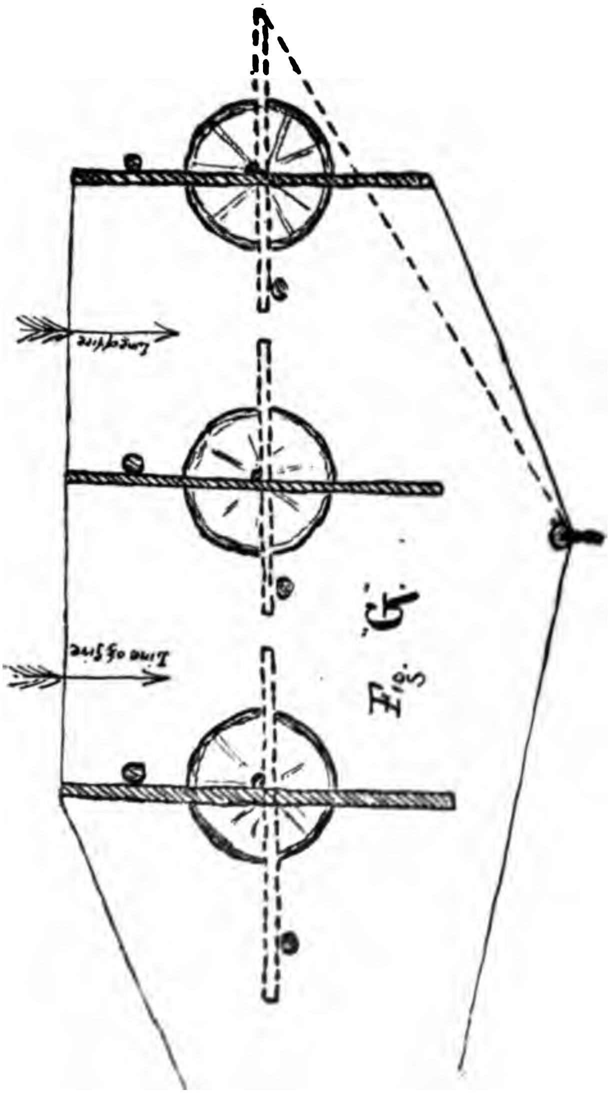


Fig. 5.

horizontal pulley the same distance apart as the targets (55 yards), the two cables are led off to the same flank and attached together, and the power (steam.—4 to 6 horses) is applied leading off about 90° with the direction taken by the target. The disappearing target consists of cloth silhouettes of men and guns suspended from a wire grill stretched between two uprights. The target can be raised and lowered by ropes and pulleys, the grill being fastened at each end to a slide working up and down on the uprights. (See sections [illegible] and [illegible].)

Fig. "H."

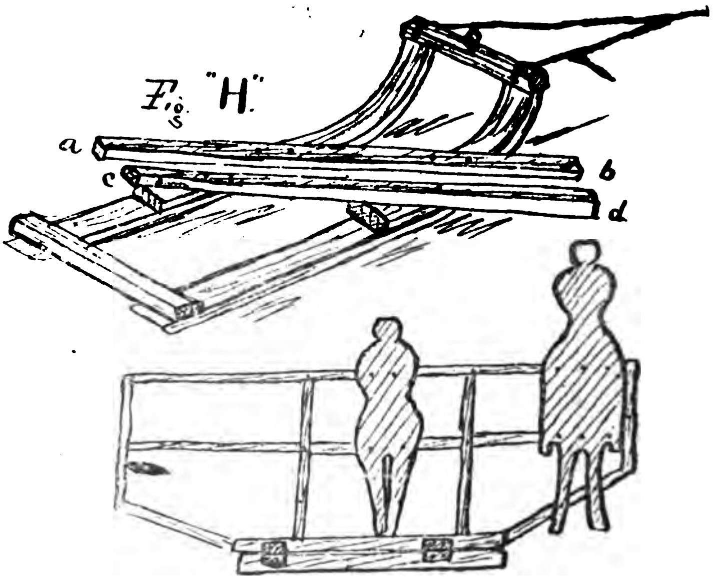
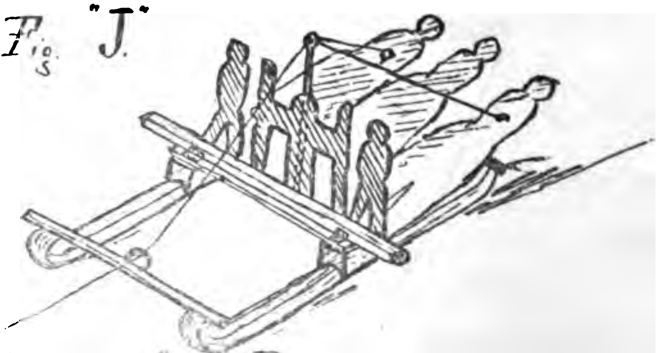
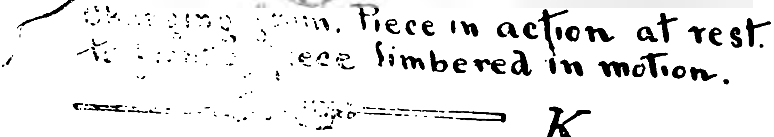


Figure "R" represents an apparatus for gunners practice at a moving target within the post. Two uprights about 20 yards apart hold two parallel horizontal wires along which a small target is arranged to slide. The motion is given to the target by a cord

Fig. "J."



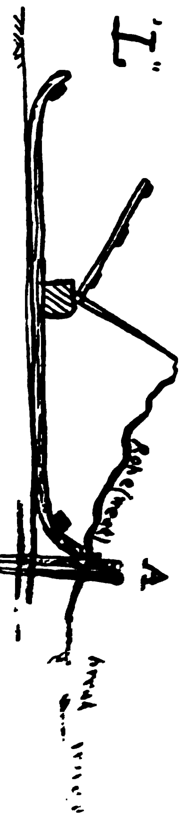


Changing front. Piece in action at rest.
At [illegible] piece limbered in motion.

K

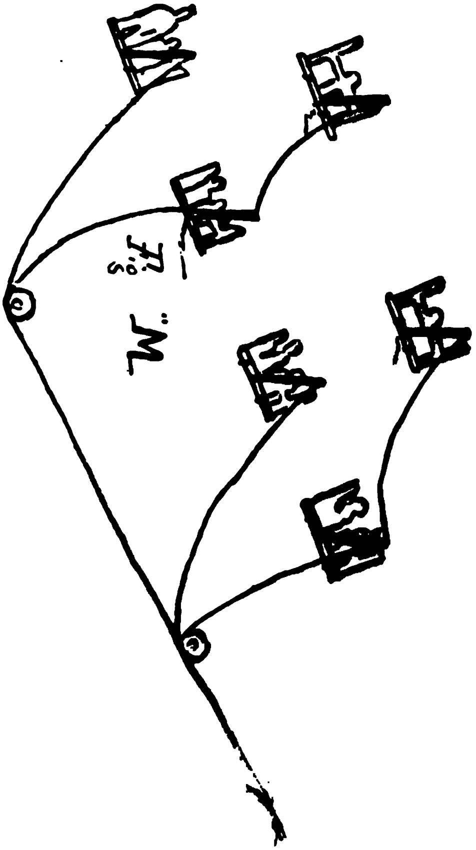
passing over two pulleys, one on each post. One pulley, fitted with [illegible] sets of wheels of such diameter that the target [illegible] moves at the rate corresponding to a walk, trot, and

Fig. "L"



Rope to break and target to disappear at a fixed point "A".

Fig. "M"



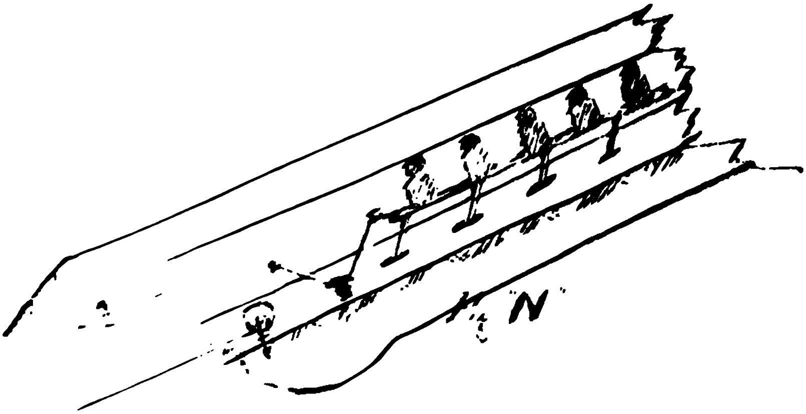
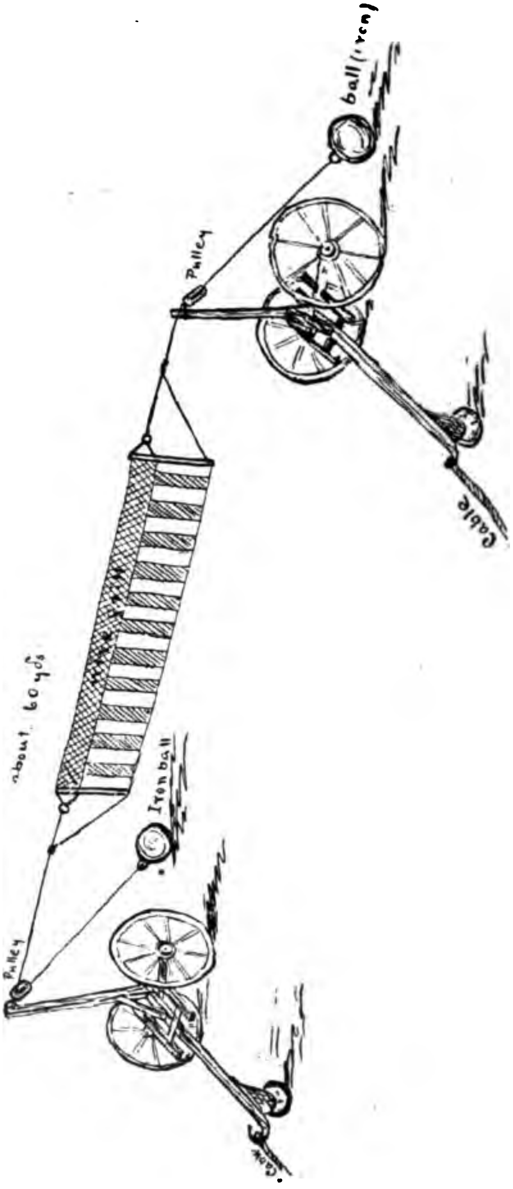


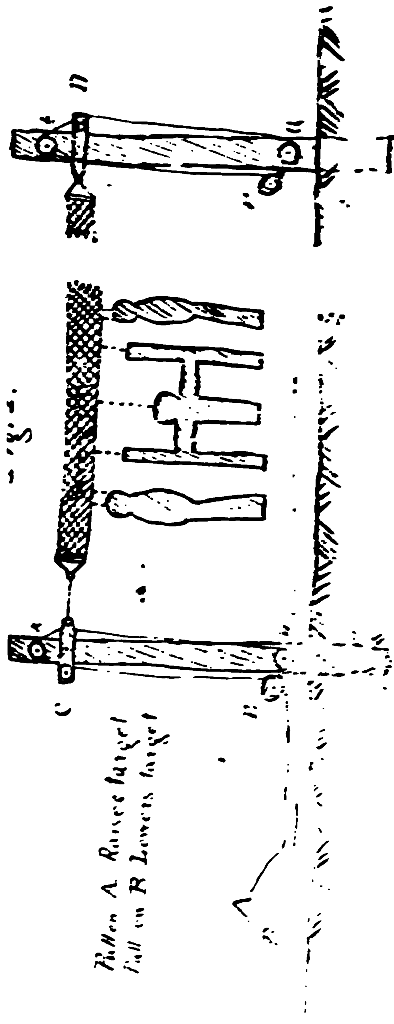
Fig O



gallop when the pulley is turned one revolution in one second, the gun being a fixed distance away.

In the instruction laid down the gunners are required to keep the gun constantly on the target by continually moving the trail.

In the practice at moving targets at this post this season (the



first Artillery target practice at moving targets in this country so far as we have been able to learn) the following forms of targets were used:

First a large roller 16 feet long by 7 feet diameter. It consisted of two board wheels 2 inches thick and 7 feet 6 inches in diameter connected by an axle, and a cylinder of slats about 8 inches less in diameter was formed between the wheels over which was tacked white cloth. The target was put in shafts about 20 feet long the rear ends weighted to form a drag to prevent the roller overrunning the cable when stopping suddenly or going down hill. The pull was made from points C and F in the figure, enough below the front end of the shafts to be in line with the axis H, so as not to tend to lift the rear end of the frame by pulling down on the front end. The suggestion of this target came from Von Schell's tactics of Field Artillery (German). The form of target gave good sfaction and is one which, I think, with proper cable can be d over the most difficult and uneven ground.

'he second form used, Fig. 2, consists of a triangular frame or ndation with a wooden runner in front and a wheel at each r corner. The target, a light frame 8 feet high by 15 feet g covered with white cloth on which was pasted two mounted ires and three standing infantry figures silhouettes.

'he frame was set up vertically on the bed and from front to r. This form of target worked very satisfactorily, but the els and the framed axle became so injured by the few shrap- fired at it, and wheels being scarce in the quartermaster

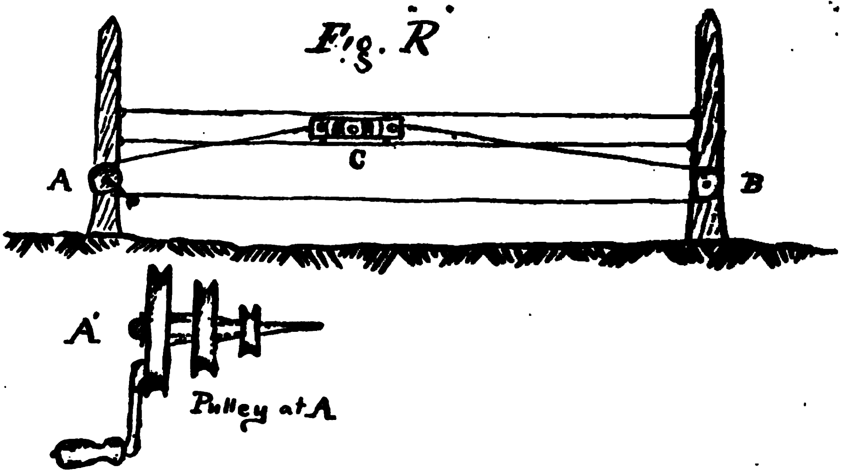


Fig. R

transportation bone yard, the form shown in fig. 3 was made, using slides behind and one wheel in front.

This form of target pulls easily but has the defect of having a tendency to run off to one side or the other when the direction of the pull on the cable is not exactly straight ahead, until the wheel gets to that point off the line when the side run is sufficient to slue it back into line. This sluing is disastrous to the wheel and to the lightly constructed frame of the target especially when moving at a gallop. Target No. 4 was then constructed having the same bed construction viz., slides behind a triangular frame and a pair of wheels in front fastened to the target by a king bolt through the front apex. A short iron tongue in front is provided to which the cable is attached. This arrangement readily adjusts itself to the direction of pull of the cable which constantly occurs from the fact that the cable does not remain absolutely in a straight line even if it was straight when starting; inequalities in the ground, brush, weeds and variation of the team from a straight line causes continual variation in the direction of the pull which if at a gallop must be quickly and readily responded to by the target.

The targets on these frames can be arranged with hinges and lever so that they can be made to appear and disappear with the pull and release on the cable and set at any angle with the line of traction of the target. (See Fig. 4).

The cable used during the practice at these targets was a No. 9 galvanized iron wire, costing 3½ cents a pound, about 15 feet to the pound, and as long as twist kinks could be kept out of the wire when laying it down no breaks were encountered. The wire was laid down and taken up on a wooden reel fixed in a battery cart. In order to provide a pulley for changing direction that would not be of too small a diameter to affect the stiff wire and not increase the pull, two wagon wheels were placed one above the other, an iron bar through the center of both driven into the ground formed the axis, and boards nailed to the corresponding spokes above and below slightly cut out on the outer edge formed the concave surface in which the cable is to run. (See Fig 5).

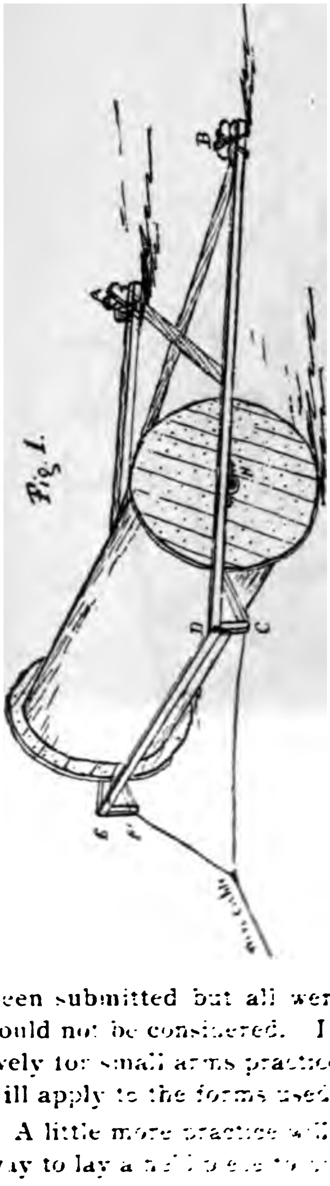


Fig. 1.

Considerable correspondence has been had with wholesale hardware dealers and wire manufacturers who have sent on samples of wire cable for inspection but all seems either too stiff or too heavy. The cable described in the German tactics seems to be about the thing and the Ordnance Department has given hopes that the necessary materials may be furnished by them as soon as they are informed exactly what is the best kind.

In his report for 1894 the Chief of Ordnance mentions that a number of forms for moving targets have been submitted but all were so elaborate and costly that they could not be considered. I imagine these targets were exclusively for small arms practice and I do not think this comment will apply to the forms used here.

A little more practice will in time develop the most desirable way to lay a field piece on a moving object. If it is moving to or from a battery and [illegible] to estimate its rate and direction it may be bracketed by the first shots and reached by the succeeding ones. Or if it is approaching a point on the ground whose range is known either by measurement or by having previously fired a shot the whole battery can be laid on this point and fired as the target approaches [illegible] This was actually done by the Germans in

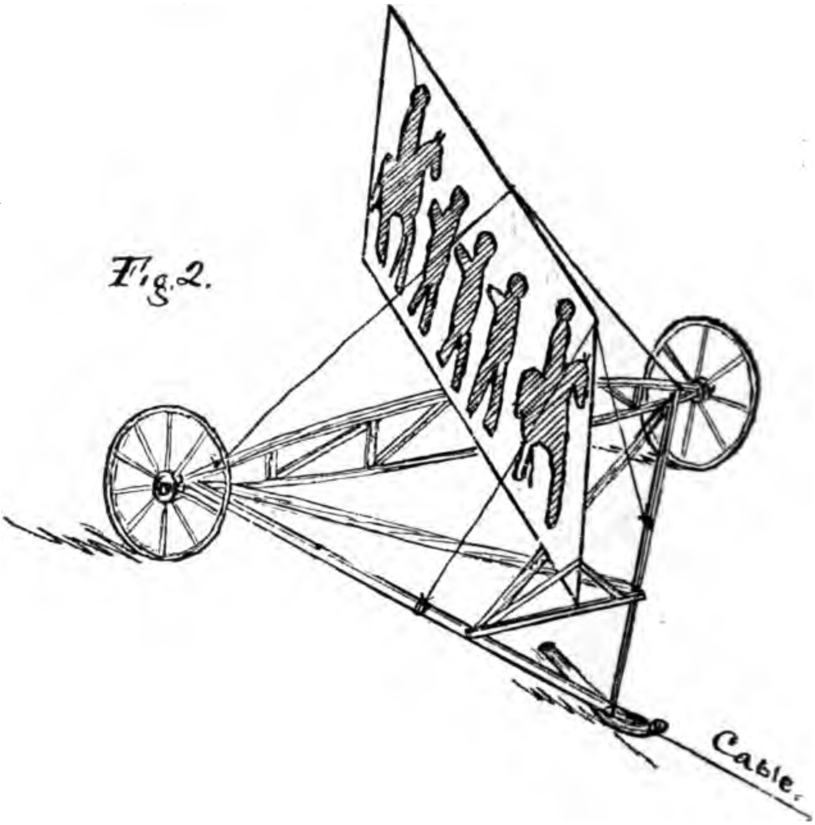


Fig. 2.

the Franco-Prussian war and a whole regiment of French annihilated.

If the target is moving across the front directly or indirectly more necessity exists for the use of the sight right up to the time of discharge. If the range is known and the pieces laid on a fixed object on the ground toward which the target is approaching, the gunner must estimate the proper distance of the target from the line of fire to allow for the movement of the target during the time of flight of the projectile.

This system involves the finding of prominent objects toward which the target is approaching, and also the uncertainty that the gunners make no error and all train on the same object in case it is desired to fire a volley.

From an examination of the range table of our field gun, taking into account the time of flight and the departure of the projectile from the line of sight, at the different ranges, for a point on the rear sight, and applying the distance passed over by the target.

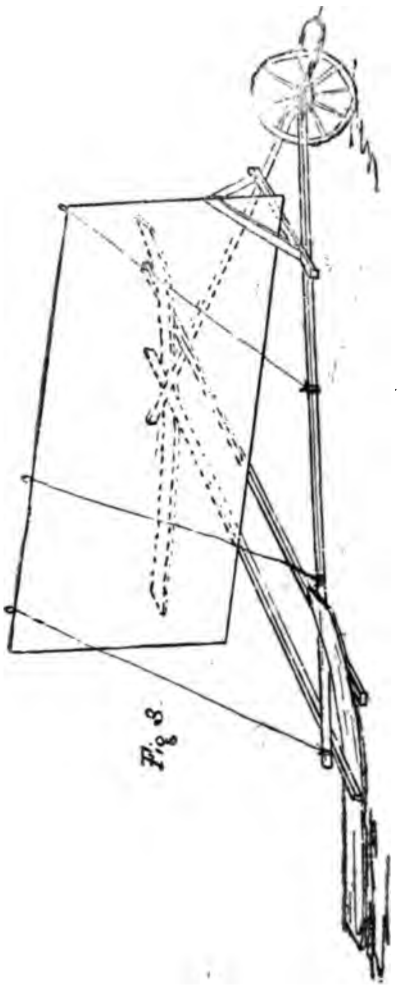


Fig. 8

6 feet per second for a walk, 12 feet per second for a trot, and 18 feet per second for a gallop (the tactical gaits) it is seen that the happy relation exist between the time of flight of the projectile and the change of position of the target at the same range, that by allowing two points, four points, and six points, for the walk, trot and gallop respectively, the projectile and target will meet no matter how far from the gun. The error in any case does not exceed the length of a horse. This was demonstrated in a paper by Lieutenant Ridgway, 5th Artillery, on Light Artillery Target Practice read the past week. Taking advantage of these conditions and believing that a sight that could remain in the piece during discharge and be of such character that the gunner standing a safe distance in rear could accurately determine when the target crossed the line of sight and discharge the piece, the following arrangement is suggested: On the top of the piece, fitting into the socket B, a horizontal bar, F G. moves right or left by a thumb screw E, and allowance can be made for wind and drift K; a thin steel upright moves right and left to points, as L, M, N, for target going at walk, trot, or gallop, from right to left. Notches 200 to 500 yards apart on upright could hold a sliding bead S, P or O, and give means of obtaining elevation; a level which would withstand shock of discharge could be attached to the horizontal bar.

Results of Practice at the Moving Targets. Season, 1897. Fort Riley, Kansas.

Light Battery B, Fourth Artillery.

Four (4) shrapnel were fired at target No. 2 (rectangle 15 feet

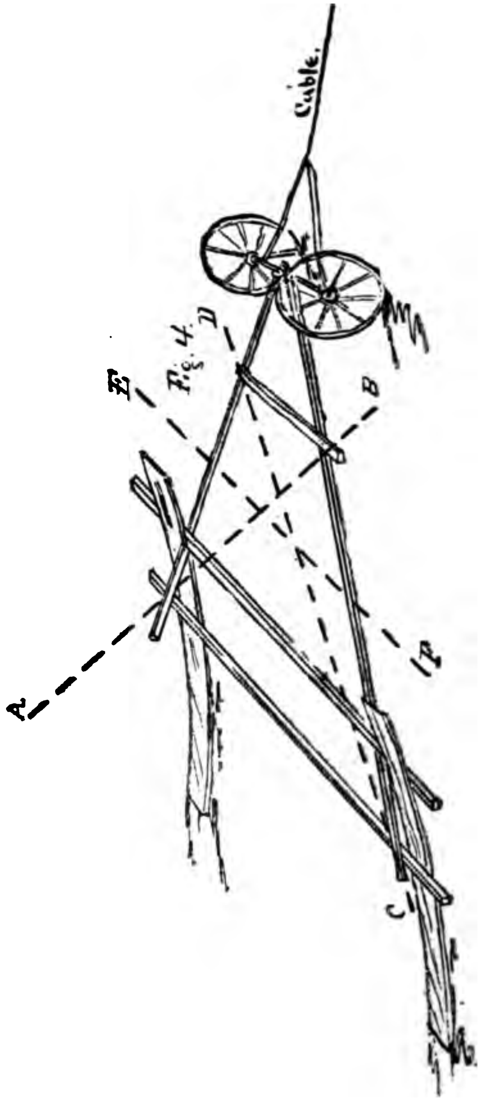


Fig. 4.

long by 8 feet high) moving at right angle to line of fire at a trot. Range (estimated) 1200 yards. Fuze was cut at $2\frac{7}{8}$ seconds and an allowance of $2\frac{1}{2}$ points left was given. Eighty-four hits were made all bursting in front except the last which burst at the target demolishing the upper right hand corner of the frame. The rear wheels of target were badly damaged.

Two series of 4 shots each (shrapnel), eight in all, were then fired at target No. 2 moving at a gallop at an angle of 65° with

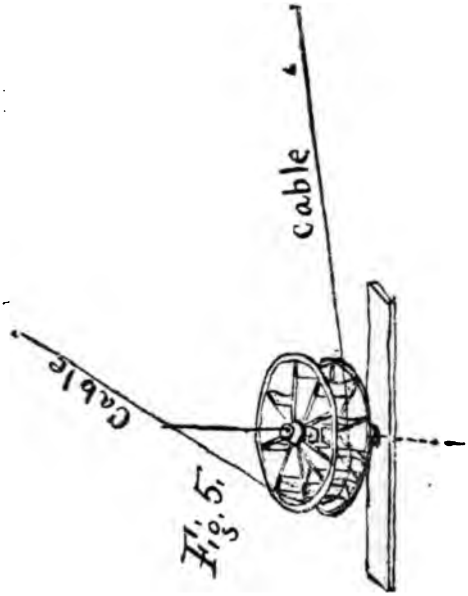


Fig. 5.

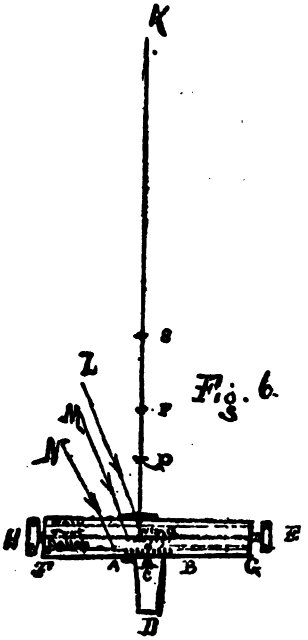


Fig. 6.

line of fire, range varying from 1200 to 1100 yards, fuze cut from $2\frac{3}{6}$ to $2\frac{1}{6}$ seconds, an estimated allowance of 4 points was given. Thirty-eight (38) hits were made.

Target No. 3 was then attached directly in rear of target No. 2 and the two moved at a gallop at right angles to line of fire. Two shots were fired, estimated range 1200, fuze $2\frac{2}{6}$, allowance (estimated) 4½ points. One (1) hit was made.

Target No. 1 (canvas cylinder) was then moved at a gallop approaching the battery in a direction about 25° to line of fire, starting at an estimated range of 1600 yards and finishing at about 1200 yards from battery. The fuzes were cut from $3\frac{2}{6}$ to $2\frac{3}{6}$ seconds. Forty-eight hits were made. No allowance.

Light Battery F, Fourth Artillery.

Target No. 4 rectangular frame 15′ by 8′, was moved at a gallop at about 80° with line of fire, at an estimated range of 1600 yards, seven shots (shrapnel) were fired, first three to burst on impact, next three cut $3\frac{1}{6}$, 3, and 3 seconds, last one impact, allowance 5 points left: five hits were made.

The same target was then moved at a trot across line of fire at about 70° from left to right at estimated range of 1350 yards receding from battery. Allowance 1 point right, elevation 1300 yards, cut to burst on impact, the target then moved back over nearly the same route, four (4) shrapnel being fired in each series. In the second series the fuze was cut at 2⅝ seconds. Eleven hits were made.

Target No. 1, canvas cylinder, was then moved from absolute cover at an 8 mile trot from right to left at 85° with line of fire, estimated distance 1400 yards, presenting little more than the end (circle 7½ feet in diameter). Six (6) shrapnel were fired, allowance 1 point right, fuze cut to burst on impact, sixteen hits were made. The last shot bursting in or so near the target that it was completely disabled, the exposed shaft and front cross piece being demolished.

This battery was entirely in ignorance of the original position of this target or its probable direction of movement.

Several methods to make the proper allowance for movement of the target during the time of flight of the projectile were employed, from estimated "hold off" used in wing shooting to giving such an allowance as would enable the gunner to lay on the target, remove his sight, get clear of the wheel and command "fire," this interval added to time of flight of projectile to the target being equal to the interval of time consumed by the target in passing from its position when aimed at, to its position when the projectile reached it. Having no sight that could be left in the seat while the gun was fired these methods were resorted to. It all furnished excellent practice and instruction and the results were considered very satisfactory. Another season the battalion commander hoped to develope the practice in a thoroughly systematic manner.

The officers in command of the batteries firing were authorized to regulate the amount of the practice and the conditions and movement of the targets.

First Lieutenant C. G. Treat, Fifth Artillery,
Adjutant, Light Artillery Battalion,
Fort Riley, Kansas.

THE KRUPP 7.5 CM. RAPID FIRE GUN IN THE CUBAN CAMPAIGN.

BY ATANASIO TORRES, CAPTAIN OF ARTILLERY IN THE SPANISH ARMY.

Memorial de Artilleria.

Scarcely had the insurrection in Cuba begun with the alarm of rebellion in Bayre, when the authorities concluded that in order to obtain the mastery over it, they must reduce the enemy by superior power, due not to numbers alone, but also to the courage, morale and drill of the troops, and especially, to the continued possession of efficient weapons: a cardinal factor in the military power of a nation.

As to the item last mentioned, the evidences of progress in that direction have of late been such that the Small Arms Committee has, only after exhaustive experiments and conscientious investigation of the matter, decided to adopt the Mauser Rifle for our infantry; and even then they have decided to make important modifications in it, that enable it to be called the best small-arm extant.

With a standard fixed by law, and made a part of the regulations on December 7, 1893, it was evident that the necessity was urgent for a change of armament of the infantry: that it should be given an arm of reduced calibre, which, on account of its perfect construction and adjustment (due to industrial and mechanical improvements) secures, by its adoption, all the inherent advantages of modern powders, which, with low pressures and without injury to the piece, give high velocities and, consequently, increased accuracy, greatly extended danger zones and far greater ranges (up to 4000 metres); in addition, it is a repeating arm, delivering many projectiles in a short time.

With so terrible a weapon in the hands of a soldier inured to hunger, thirst and fatigue, who is cheerful and not afraid to die, who is guided only by a sense of duty, who is as brave in war as he is noble and kind in peace, our infantry is able to meet any regular foreign army whatsoever.

Mountain artillery has already been used: by its effect was seen the importance of this arm and the part that it was to play in the present campaign.

The disadvantages that would follow the use of the Plasencia gun in the struggle, did not escape the foresight of the War Minister, since that piece, though it had been a good one and had given excellent results in its day, could not compete with modern guns, either in power, precision, or rapidity of fire, although great range is not an element of importance in mountain warfare. The contingencies of the future had to be foreseen, and the same reasons which led to the change in infantry arms, could be urged with reference to the artillery *materiel.* It was necessary to secure the equilibrium of the two arms, and to harmonize them.

As a solution of this question the rapid-firing gun presented itself, since an increase in rapidity of fire is one of the desiderata; yet energy is a greater requisite than rapidity. These two are difficult to combine, because the increase of mass of the projectile to produce energy, decreases, by the difficulty in handling ammunition, the rapidity of fire.

In the 7.5 cm. Krupp gun are combined power, rapidity of fire, precision and range; and to meet the requirements, the pieces rendered necessary by the exigencies of the campaign were purchased from the reliable firm mentioned, and sent directly to Havana.

The Committee on Experiments, with due promptness, set forth their ideas as to the merits of the new ordnance, in a report which was, as usual, clear and concise. As to the deportment of the piece when firing, the Committee could not have reported more favorably; but as to its transportation they were unable to give a positive opinion, for want of means of experimenting with it.

Although the parts fitted the packsaddles well enough, the saddles themselves left much to be desired; for, besides minor details, the skirts were too small, and the saddle too short, so that there was scarcely sufficient contact with the animal to ensure the stability of the load. The general arrangement of the whole, besides requiring supplementary equipments in each case, was very defective in itself, leaving all the packs very high and unstable. The defects were of such magnitude, that, from the beginning it was plain, that no amount of effort could overcome defects that could not possibly be corrected in a short time, since an almost radical change was necessary. On the other hand the circumstances did not justify the abandonment of tried, though old methods for new ones, with no certainty as to the result. The insurrection, then at its climax, demanded rapid organization, which led to the conservative use of the pieces in permanent garrisons, or in defensive batteries on the line of works between

Mariel and Majana, in order that, in the meanwhile, the Maestranza* might make a modification of the saddle or project a new one, which would have the qualities necessary for the transportation of the new *materiel.*

There was still reserved for the Plasencia piece a glorious future. Its record was so brilliant that it was not to be immediately supplanted, but was (perhaps in anticipation of its abandonment) to give additional examples of its prowess. It has many friends and advocates of every class, who know its value and its short comings; and, knowing them, feel for it the regard due its record of former service and merit.

Moreover, it served in the present campaign with commanders worthy of mention: it has triumphantly overrun the whole island under the command of the successful Captain Carles; it was necessary to play a bold and intrepid part in dealing with Jiménez Andino, in Coliseo, with Vilarragut in Galope, and with Lirón in Paso Real; to be steady and composed with Isasi, delivering its fire in high pitched notes, in a bloody collision between two once friendly armies. To it no obstacle seemed insurmountable; it climbed the hills with the same ease with which it descended into ravines, "went everywhere," according to the characteristic expression of Lieutenant Sebastian; it was the support and mainstay of the column, before the trenches of the enemy, with Lieutenant Tomé in the eastern province of Bayamo; it thoroughly proved its efficiency in the attack of villages with Saenz de Cenzano, protected with its fire, under the orders of Miñon, the well-known retreat of the battalion of Alfonso XIII, from the camp at Lechuza (a place near Curzo) to the seashore, where were four hundred men hard pressed by the incendiary legions of the insurgent chief Maceo, and performed, for six hours, prodigious feats of valor. No one opposed the idea of continuing to utilize its services, pending the solution by the Maestranza of the problem proposed to them; and, as if proud of having confided anew to it the honor of the corps, we see it bear with patience the brunt of the battle in Ceja del Negro, with Quintana and Casal, and show itself heroic in Cacarajicara with Arboledas; and, everywhere, it nobly aspires to glory, its shortcomings being atoned for by the bravery and skill of its officers.

After a careful investigation by the capable officers composing the Maestranza, particularly by Captain Riestra and the capable Campa, and in spite of difficulties of no small magnitude, which delayed their construction, there appeared two models of pack-

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Meastranza: a board of officers.

saddle, which differed from each other only in the length of the skirts and in some minor details. In these saddles nothing was retained of the Krupp model except the frame. The cover was that used on the island for the Plasencia *materiel*; the framework was of forged steel and was strong enough for any load; the wheels were suspended from hooks; the old form of bed had been replaced by small iron plates, and the weight of the whole saddle including the harness, which, in the breaststrap alone, underwent any change, was 41 kilograms.

Thus I have briefly shown the difficulties which from the start interfered with the proper equipment of the batteries of the Krupp Guns. These guns deserve, henceforth, most careful attention on the part of the authorities; and in view of the satisfactory results, when the difficulties had been overcome, I will enter fully into the discussion of my subject, and set forth the ideas suggested to me by its use in the present campaign.

In the latter part of October (1896) the Sub-Inspector General conferred on me the unmerited honor of placing in my hands the organization and command of a mountain battery of 7.5 cm. rapid fire Krupp guns, which was to be part of a mixed brigade of artillery of recent organization. There was assigned to it the following *personnel*: 5 sergeants, 16 corporals, 2 trumpeters, 16 first class, and 111 second class privates, a blacksmith and an assistant blacksmith: 152 men, all told. All these, except the artificers and non-commissioned officers (who had, almost without exception, to be appointed) came from the new arrivals, sent from the Peninsula to fill up vacancies, and had come mainly from regiments of mountain artillery. The animals for transportation were 60 mules, 4 officers' horses, and 5 spare horses. The battery was to take four guns, with a complement of five mule-loads of ammunition per gun, giving a total for the battery of 240 projectiles, of different kinds, classified as follows: 120 shrapnel, 80 shell and 40 canister. For the service of security, there were assigned to the battery 25 Mauser Argentine carbines with proper ammunition. There were sent to us for trial two models of pack-saddle planned by the Maestranza: a single model was promptly selected; since, of the two, the one with longer skirts proved, on trial, to be the better saddle.

I do not propose to enter into the minutiae of that which is common to all newly created organizations, but I consider it pertinent to give certain facts which indicate the aptitude shown by the men in handling the materièl.

The pieces were received by the battery and drill began in the latter half of October. The animals began to be received about the last of the month and were all there by the tenth of November. Almost at the same time the pieces began to come back from the Arsenal, whither they had been sent for slight alterations,[*] and instruction began in loading and unloading the packs, drilling the gunners and artificers and the battery. To this was devoted the remainder of the month. The first and last official act at which all the battery was present, was the formation that took place on the day of the Holy Patroness, while mass was being celebrated. That is to say, that after a little more than a month being devoted to organization and instruction, it must be borne in mind, in order to justly appreciate the condition for service of the new material, that all the elements, personnel, animals, materiel, pack-saddles and drill were being tried for the first time.

One hour had elapsed after the battery returned from the formation when I received the order to get ready to put the first platoon[†] on the train and take it by rail to Santiago de las Vegas. At dawn the following day began its first march on the road with the battalion of light infantry from Las Navas, joining in Bejucal the column of General Figueroa, to which it remained attached in order to operate in the province of Havana, continuing the march as far as Quivicán, which we reached at 4 p. m., spending the night at this point. At 6 a. m. on the 7th we left that town, joining in the village of Aguacate the forces of Colonel Tort and the whole column took the direction of the Heights of Seibado and Rio Hondo, where it was supposed that the enemy would be found. It was 11 a. m., the column were making efforts to approach under cover before attempting the ascent of the hills, when the first shots of the enemy's advanced line were heard. Immediately orders to advance were given. The country offered much inconvenience on account of the brambles and briars and stones. It was not long before it was seen that the enemy in considerable force, crowned the heights of Morales ; the artillery, placed in a clear space in the road delivered four rounds and, their position having been abandoned by the enemy and occupied by our troops, it was necessary to find new positions in order to dislodge them, in succession, from the heights of Volcan, Babiney, Platano (where the Lieutenant-Colonel of the light infantry found a glorious death) and Nazareno, whence we retired at 5 p. m. (not without leaving many dead, and taking with us a number of wounded) marching in column (the night having already come on) towards Campinge and Linea Plata, reaching at 9 o'clock the Santa Amelia sugar farm.

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[*] These were practically the addition of braces on the lower part of the trunnion beds to prevent the lateral play of the carriage, and the addition of an opening in the rear part of the carriage, for receiving a handspike to assist in the operation of loading.

[†] The second platoon left four days later and was attached to the army of General Hernandez Ferrer. This platoon found a permanent station in Havana, making frequent sallies into the province under Lieutenant Franco.

This march was one of the most difficult ones made by the platoon, because, neither the men nor the animals were accustomed to fatigue or privation and here they had to endure hardship, without eating or drinking at any time during the day, having to load and unload the material a number of times in changing position in order to cause a change in the enemy's lines. In order to do this, the guns had to be moved and fired with all the rapidity possible under the circumstances, the way being frequently over broken and difficult ground. Finally, the difficulty and monotony of night marches, aggravated by such accidents as mules falling down etc., completed a long day of trials; and fortunately our commanding general expressed only entire approval of our work.

The battery continued its work among the hills included in the quadrilateral formed by Managua, San Jose de los Lagas, San Félipe and Bejucal, making, usually, marches of eight or nine hours with loaded material. This lasted until the 20th, when it was sent to Manzanillo, to join the brigade of General Hernandez Ferrer, forming a part of the division under General Bosch, which devision was intended principally for the protection of convoys from Manzanillo to Bayamo and other points in that jurisdiction, such as Giguani, Guira and Cauto.

A detailed and exact description of the disposition of the forces, has no place in this article; nor have the order of battle, or the various accidents of the ground in the different engagements in which the platoon took part; but it seems pertiment to say that conducting convoys is one of the most difficult of military operations. The attitude of the escort, being essentially defensive, requires that the desire to attack be restrained and that all efforts be directed to the main object of the escort: which is simply to force a way for the convoy, when it is necessary to do so. To this end there must be a strong advanced guard to discover and repel ambuscades and surprises. and to capture and occupy important positions; and this guard should be always composed in part of artillery. The principal danger to a convoy is on its flanks, which necessitates the detail of numerous forces for reconnoissances, in order to obtain a thorough knowledge of the roads and cross-roads. The fights in which the vanguard engages are nearly always bloody, since the enemy compels it to adapt itself to surrounding conditions, as at the ford of a river, on the other side of which is a position strengthened by trenches, or when the road is obstructed by fallen trees or other obstacles that compel the detention of the convoy under fire, the enemy being perhaps under cover of the bushes and thickets, where he finds such safe refuge, knowing his bearings. Under such circumstances, marauders and adventurers find themselves at an advantage, while regular troops suffer, since, in fighting in the brush, they are much exposed, and adequate control and command of the individual is rendered impossible.

This explains why the enemy's forces, relatively protected, can prove to be a serious obstacle to the march of a convoy.

In obedience to these general principles, the two platoons, one belonging to each brigade, marched always in the advanced guard. The platoon of Plasencia guns, commanded, with intelligence and decision by Lieutenant Tomé, shared with mine the fluctuations of fortune.

On the 8th of January, in the "Cienaga de Jacaibama," after the removal of an obstruction of trees extending over more than 200 metres, the platoon protected with its fire the rear guard of the convoy, which was attacked when the road was being opened for the passage of the wagons. We fired over the heads of our own troops, sparing our two lines of fire, and taking as a target the smoke made by the guns of the enemy, which was perfectly visible, because they used the Remington arm. On the 26th of the same month in "Sabana Barranca," the two platoons protected with their fire the advance of our infantry, which charged the enemy and drove them a considerable distance into the forest. On February 1st, in "Potrerito de la Villega," and on the 5th in "Babatuaba," their shrapnel fire utterly routed the insurgent hordes. On March 3rd, in the valley of the river Buey near the "Caimito," the enemy held a commanding position, strongly intrenched, with the river in front and an absolutely safe line of retreat, and it was necessary to demolish their works with the fire of the four pieces, compelling them to abondon their position, though the column suffered some loss. Finally, in the valley of the river Cautillo, while assisting in the protection of the village of Giguani, which was besieged by the insurgents, the platoon protected with its fire a flanking battalion that met with resistance.

Along the roads, the pieces were generally *drawn*, except on difficult portions of the road, such as rivers, and broken country; or on rainy days, when the mud did not permit it, or on considerable stretches of road that were naturally muddy.

The platoon remained for the purpose of protecting convoys and of taking part in some operations in the neighborhood of Bayre and Cauto, until March 26th, when it marched to Ciego de Avila, in the military division of Júcaro á Morón, where it remained as light artillery of the line, until May 1st, when it was provisionally attached to the brigade of General Ruiz, with which brigade it was constantly engaged in military operations, until the 17th of the same month, when it returned to Ciego de Avila. In this expedition the platoon took part on May 3rd, in the fight at the "Reforma" ranch, which resulted in the occupation of the enemy's camp situated on the other side of the river of the same name. In "Pelayo," "Trilladeras" and for the second time at the "Reforma" ranch, it effectively intervened, now defeating the hostile cavalry at long range, now assisting to dislodge them from camps and commanding positions, taking tactical positions, according to the surroundings, and always governed by the directions of the indefatigable General, who with men and animals on half rations, kept in constant motion the army of the insurgent leader, Maximo Gomez.

In the latter part of that month, in consideration of the satisfactory result of the campaign, the general-in-chief ordered the dissolution of the mixed brigade, giving me a verbal order at Ciego de Avila to take the platoon back to Havana.

After this brief sketch, it is proper that I should give my impressions,* it being understood that they pretend to only a relative value, in view of the kind of warfare. The numbers and character of the enemy, his system of armament, the character of the terrain, and especial tactics of the engagements, characterized by the absence of artillery among the enemy, make it evident that the platoon has not played a part so important as that which it would have played, had its appearance been justified as a necessity of modern warfare.

The piece being known to all the readers of the "Memorial" by the description given of it by General Carrasco in June, 1896, I need not praise its excellent qualities.

The use of the metallic cartridge does away with the inconveniences of obturation giving a fermeture of rapid and easy manipulation, composed of durable parts. These parts can be easily taken apart; and the striker, spring and needle replaced in a short time; the cartridge is withdrawn by the extractor with absolute certainty; and there is an arrangement for eliminating recoil and one for making slight changes in pointing. This piece has a range of upwards of 3500 metres with corresponding accuracy of fire, delivering a projectile of 6 kilograms weight, with considerably increased velocity. All these attributes make the piece an element of terrible power.

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* These with slight variations are extracted from the report directed by me to the government in June last.

But it would not meet the requirements of mountain warfare, had it not moreover, to the fullest extent the mobility necessary to accompany an army to the theatre of operations. Therefore, it must be discussed from three points of view: its service qualities; its fitness for transportation; its behavior under fire. It is a tactical principle, and the foundation of all instruction that the battery should be able to pass rapidly from any formation to that in battery and *vice versa*; and with the same promptness to use the pieces with the object of gaining the advantage from the start. Hence, first of all, the artillery *materiel* should be capable of being promptly and easily packed and unpacked; next, that it should have certainty of action and a simplicity of mechanism, adapted to the intelligence of the cannoneers, and that inaccuracies of fire should be promptly corrected.

From the first of the three points of view, it must be borne in mind that it takes six operations to pack, and as many to unpack, these being necessitated by the dismounting of the gun carriage, loading separately the wheels and the piece composed of the trail and axle; but such work is simple, and exacts only thorough instruction of the *personnel* and methodical and exact drill, making each man take his turn at it, so that he will convince himself that what appears complex work at first sight, takes when compared with its analogue in the Plasencia system, a very short time, such as is perfectly allowable for unpacking the piece.

As to the [illegible] of separating the axle from the trail, the consideration [illegible] in unpacking diminishes the [illegible] as regards [illegible]

The [illegible] not less [illegible]

The [illegible] artillerymen [illegible] then first of all [illegible] and they [illegible] duties, permitting him to follow quietly the vicissitudes and changes of fortune of the fight.

Fuse cutting, after a little practice, is performed by the artificers with relative ease, as is, also, dismounting and assembling the parts of the piece; nor does the manual of the piece give any difficulty.

With ten men and a chief of piece for its service all the positions are completely filled, without undue fatigue to the men concerned, in spite of the idea that a greater number might be used with the object of shortening the time of work, or increasing the convenience; a result which is imaginary, as the men get in one another's way and hinder movement. Good effect is obtained not by numbers, but by giving to each man an opportunity to discharge his particular function. Moreover it would not be prudent to use less than that number; for, frequently, a smaller number only is available, as happened to us on more than one occasion, when it had to be done with eight men, notwithstanding the fact that we began operations with five supernumeraries.

The above method of instruction may be used, or else that laid down in the manual of the old piece, varying, as occasion requires, the interval between the pieces in the formations in line and double column, observing that each piece has an extra load.

As regards mobility it is known that the ordinary means of transportation of mountain artillery is on the backs of mules, using the shafts, however, for drawing it along suitable roads. There must, then, be considered the conditions of (*a*) the load, and (*b*) the traction of the *materiel.*

Comparing the weights of the loads as I distributed them, with their analogues in the Plasencia system, and allowing the same weight for the pack-saddle, it is found that the load of the carriage and that of the wheels weigh more in the Krupp than in the Plasencia system; the other corresponding loads are lighter, particularly the ammunition loads in which the difference in favor of the Krupp gun exceeds 20 kilograms. In the load of wheels the excess is only 5 kilograms, and, in the carriage load, in which, as above stated, the Krupp system is at a disadvantage, the weight is, notwithstanding, included between 160 and 170 kilograms, which is generally accepted as an ordinary load for a mule, as it does not exceed 180 kilograms which, as a maximum load, can be easily carried, including the weight of the shafts.

The principal inconvenience of the carriage load (besides its weight) is the height of the load, which exposes it to continuous vibration, and to unbalancing. It is considered preferable to raise the carriage to the mule from the wheels, leaving the axletree on the carriage, as this slight increase of weight is more than compensated for by the stability that this gives to the load; an increase of weight of 3 or 4 kilograms amounts to little, while nothing is more trying to the animal than an ill-distributed load.

As regards traction, more effort is required on the part of the mule, than in the Plasencia piece because of its greater weight. The height of the muzzle above the ground being considerably less than in the old system, it is more difficult to draw in marching along roads slightly rough; but this same characteristic and the strength of the wheels give it more stability and better conditions of draught along good roads and highways.

The disadvantage of weight is increased by the poor arrangement for draught, which makes the carriage move irregularly instead of at right angles to the axle making it necessary for the shafts to readjust their direction and that of the carriage. It is desirable not only to correct the defect mentioned but also to avoid premature destruction of the connecting bar, due to throwing all the strain on the bar (connecting the shaft with the trail), which causes the brass collar that holds the bar in place to move laterally; and the destruction of the wood due to the excessive play of the bar in its collar causes the point of junction to lower until it reaches the shafts touching the animal, and making it impossible to use them.

The adoption of two rings with a sufficient length of chain (for purposes of traction) extending from hooks on the axle to the point of attachment of the single-tree reduces very much the work of the mule in drawing it, and eases his movements by permitting a slightly better adjustment of the breast leather; and, furthermore, two mules can be conveniently harnessed to it, as is sometimes done.

As we have seen, the piece cannot be considered heavy, if we regard its elements in detail; nor is the divisibility of the carriage a defect, if we consider the ballistic qualities which it possesses; but certainly in my humble opinion, the projectile should be reduced in weight to 5 kilograms, as it would then have still the power necessary for its purpose, and the ultimate weight would thus be reduced, increasing the ease of transportation and partly solving the question of ammunition, which is the only objection that can be imputed to the system, because it involves an excessive number of loads per battery, requiring too many animals and adding nothing to the simplicity of the old batteries.

Except in the respects indicated, the present piece is transported perfectly over all kinds of ground, stands the marches well, and can be placed in battery in a short time.

The pack saddles have already been discussed at some length. But, without begrudging them their merits (which I am glad to recognize, as they helped to solve an extremely difficult problem), I must say that they have not entirely justified the enthusiam that I felt when they were first tried. The adaptability of the trail and trunnion beds to the process of loading is, I believe, well understood. The surface of the saddle is not so satisfactory, since, instead of keeping the trail in place, where it conforms to the animal, the saddle allows the trunnion beds to slips too far forward. This may be due to a springy effect arising from the elasticity of the little plates of iron ; at any rate the result is that, after a short time of use (during which the load fits the bed) the saddle is deformed.

On the question of padding, opinion is divided ; there are those who prefer wool as more elastic and making the saddle more comfortable for the animal, by fitting better ; while those who advocate goat's hair allege that, in its turn, it is cooler for this climate and more easily obtained ; that a good fit with this material is obtainable under favorable conditions with skilled workmen. Nothing less than actual experiment with both systems can rationally determine which is to be accepted ; although I am inclined to believe that I would immediately decide in favor of the former.

Perhaps the effects produced by the shortness of the saddle, have been exaggerated ; for in view of the discussions of the new loads the shortness means diminution of weight, which may be considered as a compensation. For when we compare the new loads with the old, we find that the carriage is the only load in the Krupp system that weighs more than its analogue in the old.

The defects mentioned, though they are important, do not amount to so much that they prevent it from performing satisfactorily its peculiar function ; but they should be considered if its permanent adoption is thought of.

In considering the *material*, it remains to refer to the behavior of the piece in firing. In the different engagements which have been so imperfectly recorded, I seized the opportunity to try different kinds of fire. I will give some of the results that may serve as data for conclusions.

We fired with shell at "Potrero Pelayo ;" with shrapnel (after using shell for bracketing) in the fight at "Caimito ;" shrapnel for percussion at "Jucaibama" and shrapnel for time at "La Reforma;" altogether 38 shell and 70 shrapnel consumed in the six months during which the platoon was engaged in military operations.

Of these, I may say that the shells burst in a very satisfactory manner. Their power of penetration may be judged by the effect of one of them in "Potrero Pelayo" which penetrated one metre into the sloping bank of the river, opening a cavity having a diameter slightly greater than that of the projectile, and disturbing, by its explosion, a column of earth about a metre in thickness, throwing out a part of it.

When we were encamped at "La Reforma" there was recovered a shrapnel, intact, except that the fuse had been blown out and also the interior tube and all the charge, tearing away, however, that part of the ogive into which the fuse was screwed; as, indeed was intended in its construction. This was the only projectile found in that condition, and from this, may be seen that the shrapnel broke and utilized the cases, which on the other hand, did not affect its value, since the shell, as is known, retains the remaining velocity, that of the bullets being increased by the velocity due to the bursting charge.

As, in most cases, the enemy was on the heights, it is not possible to vouch for the effects of the fire, on account of the facilities offered by the ground for carrying away their dead, unseen; this same characteristic of the ground made it correspondingly difficult for us to make reconnaissances. At the "Pelayo" and "Reforma" ranches, the zone of fire being relatively open, I may state that the place where a shell exploded was surrounded with blood, and in an adjoining cemetery were three new graves. At "La Reforma" a horse was found dead with seven shrapnel bullets in him. In the fight on the 7th of December, one of the reconnaissance parties reported that the explosion of a shell had caused the death of four insurgents in a village situated in the zone of fire.

The powerful bursting charge of the shrapnel, allows its substitution for the shell, employing it in percussion fire and keeping the shell for objects more difficult of penetration. For the same reason, the point of burst, in time of fire, can be observed by the quantity of smoke produced. The number of balls and their living force suggest their employment in preference to canister at point blank ranges. This would involve a change in the proportion of the different kinds of projectiles in the pack; so that each load would contain 8 shrapnel, 3 shell, and 1 canister.

Feeling, as I do, the necessity in mountain warfare of curved fire, (as the shrapnel do not begin to be effective against a short target until the angle of fall approaches 20°, corresponding to a range of 3400 metres, at which distance a battery can rarely be established), I think that it would be advisable to furnish cartridges containing reduced charges—two of these to each load—painting the shrapnel with a different combination of colors in order to distinguish it.

The fuses acted remarkably well, as there was no case in which the bursting charge of shell or shrapnel had failed to explode; nor did the fuses fail to respond to the time scale. Similarly, at no time did the percussion caps of the cartridges fail to communicate fire.

As to rapidity of fire, it is known that this depends on promptness in loading, due to the use of the metallic cartridge, which substitutes a single motion for the three motions of inserting the projectile, introducing the cartridge and adjusting the friction primer; and on rapidity of pointing due to the obviation of recoil by the use of the trail plough.

As regards the latter, it was only on a few occasions that we were able to employ it in a war like the present one, in which surprises were the rule, and the pieces were rarely in position more than a few moments. Thus it is always desirable that an artillery officer should be able promptly and judiciously to choose positions and rapidly move into them; a mountain artilleryman *must* have these characteristics. They embrace placing the battery in position and using it effectively against the enemy.

From this it follows that, the time being brief, the loss of time in putting the trail plough into its firing position is excessive, when the enemy, suddenly appearing, opens fire, or when the position is a momentary one and activity is necessary in order to pass rapidly from one position to another, The trail plough has its use when we can take advantage of its valuable attributes, as when there is time after discovering the enemy to correct the fire, which involves occupying the position for some time; in a word, when real artillery fire takes place. In such case the plough should be down in order to avoid moving the piece by hand to the front, since this movement involves loss of time and unnecessarily fatigues the cannoneers; and in rapid fire, it is absolutely necessary to supplement rapidity of loading by rapidity in pointing.

As to opportunity for firing rapidly, *that* has to be secured by prompt decision, and the first necessity in it is correction of fire, requiring that the service of the piece be performed calmly and with care; the only safe way of efficiently using rapid fire. The fact that the pieces are called "rapid fire" guns, does not necessitate that, from the first moment, they should be fired at their maximum rate; such a course would waste many shots, and expose one to lack of ammunition when it is much needed.

In the precision and power of the piece, in the excellent quality of its projectiles, in the confidence inspired by the accuracy with which the cannoneers fire, in its range which allows to be chosen good positions and angles of fall such that shrapnel will be effective against troops more or less hidden, lies, ordinarily, the superiority which the new *materiel* represents. This leads to the belief that one or two accurate shots are worth more and have a greater moral effect than many wild ones.

In firing, ordinarily, during a fight, the piece is capable of firing as rapidly as the commands can be conveniently be given. If results are noted after each shot a piece can always be held in readiness, loaded and pointed.

As regards the number of shots per minute, its maximum rapidity of fire is, according to its constructor, eight shots per piece per minute; but although I cannot be absolutely positive, in the opinion that I have formed in firing with shell, and especially with shrapnel, I believe that, under actual service conditions, one cannot hope for a greater rate of fire than from one half to one-third of that claimed for it.

The above shows the favorable estimate that the Krupp 7.5 cm. cannon has earned with me. The working of its different parts being obsolutely certain, without interruption or necessity for replacing springs, strikers, or needles (an operation performed by the artificers in a short time and with extreme ease), deserves absolute confidence on my part.

Some modifications are necessary in the ammunition chests which are the defective part of the *materiel.* The fastening of the lid should be placed inside to avoid its injury by catching on shrubs and branches of trees; the character of lock should be changed; and the chests strengthend with strong armor.

The adoption of this piece constitutes a great advance in the mountain artillery and places it in condition to compete with advantage with those of its class in the possession of other nations, or to reduce to silence *any* piece, whatsoever, that is in use among the insurgents; and it has all the qualities claimed by modern artillery, although the *heroes* that fought against it do not appear to have great confidence in its power.

[Translated by Second Lieutenant *Alston Hamilton*, First Artillery.]

CONTRIBUTION TO THE STUDY OF THE PROBABILITY OF FIRE OF COAST ARTILLERY.

By Giuliano Ricci, Captain of Artillery.

Rivista di Artiglieria é Genio.

The study of the probability of fire of coast artillery, against vessels in motion, presents itself under such complex and varied conditions that it is difficult and perhaps impossible to determine with a general and complete solution, the per cent of the useful hits which may be relied upon in a series of shots that reproduce the tactical and technical condition of battle fire.

We may instead, however, find various partial solutions referring to special cases, and by means of these be able to collect some data to form certain criteria both from a tactical and technical point.

It is proposed to study here one of the simplest cases, which will not always correspond, it is true, to war conditions, but which may, however, serve as a point of departure for the examination and discussion of all other cases.

We assume two hypotheses, which determine the conditions of the problem we intend to discuss.

We will suppose

1st. That the firing has been corrected, that is, that all the causes of error which might systematically alter the results of the firing have been previously eliminated, and that the accidental errors alone need be considered, then errors being variable in sign and value in accordance with Laplace's well known law, which formed the basis for the calculation of the table of factors of probability generally adopted in ballistics.*

2nd. That the observation of the movement of the target during a certain interval furnishes a means of adjusting the aim or of anticipating the position of the target at a given subsequent instant. Such an hypothesis is verified by the method of aiming now generally employed and includes within it the further assumption that the target moves with uniform motion over a right line during the time occupied in the preparation for firing.

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* The greater or less density of the atmosphere will diminish or increase, systematically. the range; if the piece be worn out or the powder poor, the range will be systematically short; finally, the aiming of a given individual may be systematically too high or too low, Theoretically, these systematic errors can be eliminated by preliminary firing.

Besides systematic errors, however, there are accidental ones inherent in the piece, in the aiming and in the measuring of the distance which cannot be corrected and on which the accuracy of fire depends. These errors are dispersed according to the law noted above.

In regard, however, to these hypotheses and to the confidence which they may deserve in practice, we must observe what follows:

a. The corrected firing against a movable target will be attained with difficulty, and even when attained, it will be almost impossible to keep it so.

Indeed, though the causes of the systematic errors may remain a maximum (some, for exomple, the wind, may vary) their effect varies with the distance and also with the direction of the firing. The corrections which must be applied to the data of firing to keep it corrected changes, therefore, continually, and we have no means of calculating it at every discharge with sufficient accuracy.*

The difficulty of attaining and maintaining the fire corrected will be the greater as the variations of the systematic errors from shot to shot are greater; it increases, therefore, with the velocity of the target and diminishes as the rapidity of fire increases.

b. It is certain that a vessel during battle will not always maintain a rectillinear route nor will it always move with a uniform velocity. Theoretically, however, it is still possible to predict the position of the target at a particular subsequent instant, even though the route is curvelinear, and the velocity variable, provided that in the interval of time required in the preparation for the firing, the movement of the vessel is maintained continuous and does not become altered in direction or velocity, from any cause, such as a variation in the number of revolutions of the propeller.

It is even possible to imagine or devise some method of solving this problem practically.

We do not occupy ourselves with this case, which, as far as we know, is still unconsidered in the field of applications.

Perhaps in this case the results will not differ materially from those which would result when we assume the motion to be uniform and in a right line. If, then, the movement of the target is not continuous, being abruptly altered by the will of its operator, it is certain that whatever be the adjustments, imagined and imaginable, of the firing, it will fail. We must, then, no longer depend upon the precision of the shots but rather upon their dispersion. The discussion, whether it would not be proper o increase this dispersion artificially by employing graded elevaions and displacements, is an absolutely distinct case which will reated separately.

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* The corrections proportional to the distance, although theoretically cor
practice, give sufficiently accurate results, especially when, as in howitzer fi
are varied.

As we have before stated, it is certain that the route of the vesel will not always be a right line, nor will its velocity be uniform; are almost equally certain that the conditions of its movent will not permit a very frequent departure from this double ypothesis, unless the vessel renounces what strength of fire it ossesses, or, the target at which it is to fire is very small in exent.*

In some cases, moreover, tactical and hydrographical circumtances might concur to limit the free maneuver of the vessels.

From what has been indicated, it follows that the results obained will be considered only as a superior limit which will robably never be reached, but which it is possible to approach nder certain favorable circumstances. We hold that these cirumstances will present themselves with sufficient frequency, but he experience of war will alone be able to decide this question.

Finally, we observe how, having given the methods generally mployed in the firing of coast artillery, the problem here proosed corresponds to the theoretical case admitted as general and undamental. We observe, too, that all other cases, (in which, ither some systematic error is not eliminated, or the adjustment f the fire is found to be defective through an alteration in the novement of the target,) may be made to depend on the general ase, in the same manner that the problem of uncentered fire is nade to depend on centered fire.

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In order to determine the per cent of useful hits which may e obtained against a certain target under any conditions whatver (limited, however, by the above mentioned hypotheses) it uffices to know, for the present:†

1st. That which is to be found on the subject of the calculaion of probabilities in the "Artillery Practice Instructions," old olume vii, chapter ii, and in the Manual of Artillery, part iv.

2nd. A theorem of the calculus of probability which is exressed thus.

"When many independent causes produce effects of the same direction, we may, knowing the probable errors e_1, e_2, e_3.... which would result from the operation of any isolated cause, find the error E which results from their simultaneous action, thus,

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* This deduced from an examination of the conditions under which a vessel [illegible] ires at a land target. Such fire is evidently [illegible] by the same causes of error as [illegible] nherent in a land battery firing at a vessel in [illegible] and in a greater [illegible] nstability of its platform and the [illegible] s is abundantly confirmed by the [illegible]

† It is believed preferable to [illegible] rmy officers, rather than [illegible] tudy.

$$E = \sqrt{e_1^2 + e_2^2 + e_3^2 \ldots}\,^*$$

Applications:

1st. The probable error in range of a shot from a piece aimed with absolute precision, at a certain distance, is 10 m.; at the same distance a gunner commits an error in aiming such, that the range due to this cause alone, would give a variation whose probable error in range, E, of the shot with this particular gun and gunner will be

$$E = \sqrt{10^2 + 20^2} = 22.4 \text{ m.}$$

2nd. Assuming that we know the elevation which must be given to a particular piece to attain any mean range whatever, let us consider a piece which for a certain distance and for distances varying but little from this gives a probable range error of 15 m., and that the range-finder used to determine this distance under similar circumstances, is susceptible of an error of 30 m. The probable range error of the shot made under these conditions will then be

$$E = \sqrt{15^2 + 30^2} = 33.5 \text{ m.}$$

3rd. If AB, measured by any means gives a probable error of

7 m. and BC measured by the same means yields a probable error of 20 m., the probable error in measuring AC is

$$E = \sqrt{7^2 + 20^2} = 20.17 \text{ m.}$$

We now come to the solution of the proposed problem.

Let the target be horizontal and rectangular in form and let one of its sides lie in the direction of the fire. Let A be the length of this side, and B that of the other dimension. Let M and N be the depth and breadth of the zones containing 50% of the shots of a given piece fired under certain determinate conditions— a length and breadth which result from the combination of the various causes of error which may affect the fire (error of the piece, of the gunner, etc.).

The per cent of the useful shots will be given by the expression

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* This is a theorem which, on account of its important applications, ought, in my opinion to be embodied in our Artillery Manual (author).

$$\frac{1}{100} \, P\left(\frac{A}{M}\right) P\left(\frac{B}{N}\right).$$

In order to solve the proposed problem we have only to substitute for A, B, M, and N the values which result from the true dimensions of the target under consideration and from the conditions of the firing.

Let $a\ b\ c\ d$ (fig. 1) be the contour of the horizontal projection of a vessel—a contour which we may assume represented by an ellipse having for axes the maximum length and breadth L and l, of the vessel—and h the mean height of the useful target which the vessel presents. Let θ represent the angle of fall and mn, which makes with ab the angle ψ, the direction of the plane of fire. Let us project upon the sea by means of the trajectory, the contour of the main bridge of the vessel, we thus obtain the ellipse $a_{,}\ c_{,}\ b_{,}\ d_{,}$; and the effective target which the vessel presents will be equivalent to the horizontal boundary of the contour $p\ m\ q\ q_1\ n_1\ p_1$, *i. e.*, of portions of two ellipses and of two tangents common to them and parallel to the plane of fire. We will assume (and we can do so with great approximation) that this last target is equivalent to a rectangle whose length is $mn = A$ and whose breadth B is such that its area is equal to that limited by the boundary $p\ m\ q\ q_1\ n_1\ p_1$.*

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[*] Let $A = mn + \frac{h}{\tan\theta}$.

To find mn proceed as follows:

The equation of our ellipse whose axes are L and l is

$$\frac{x^2}{L^2} + \frac{y^2}{l^2} = \frac{1}{4}.$$

From the figure (1a) we have

$$x = \frac{1}{2}\,mn\cos\psi$$

and

$$y = \frac{1}{2}\,mn\sin\psi$$

Substituting these values of x and y in the above equation and solving for mn we obtain

$$mn = \frac{Ll}{\sqrt{l^2\cos^2\psi + L^2\sin^2\psi}} = \frac{Ll}{\lambda}$$

when for $\sqrt{l^2\cos^2\psi + L^2\sin^2\psi}$ we substitute λ.

Substituting this value of mn in the first of the above equations we obtain

$$A = \frac{Ll}{\lambda} + \frac{h}{\tan\theta}.$$

The area enclosed by the contour $p\ m\ q\ q_1\ n_1\ p_1$ is equal to that of the ellipse having L and l for axes plus that of the parallelogram $p\ q\ q_1\ p_1$. The area of the ellipse is ¼ π Ll and of the parallelogram is $\frac{h}{\tan\theta}\,st$. Now st is the projection of the diameter pq upon the right line perpendicular to the plane of fire; let ψ be the angle between the two conjugate diameters pq and mn, then will $st = pq\sin\psi$, but from the well known property of conjugate diameters we have

$$(mn)\,(pq)\sin\psi = Ll.$$

Hence

$$st = \frac{Ll}{mn} = \lambda.$$

Finally we have

$$B = \frac{\frac{1}{4}\,Ll + \frac{h}{\tan\theta}\,\lambda}{A}.$$

By means of the characteristic relations between the elements of an ellipse, we find

$$A = \frac{Ll}{\sqrt{l^2 \cos^2 \psi + L^2 \sin^2 \psi}} + \frac{h}{\tan \theta}$$

$$B = \frac{\frac{\pi}{4} Ll + \frac{h}{\tan \theta} \sqrt{l^2 \cos^2 \psi + L^2 \sin^2 \psi}}{\frac{Ll}{\sqrt{l^2 \cos^2 \psi + L^2 \sin^2 \psi}} + \frac{h}{\tan \theta}};$$

Placing

$$\sqrt{l^2 \cos^2 \psi + L^2 \sin^2 \psi} = \lambda$$

we obtain

$$A = \frac{Ll}{\lambda} + \frac{h}{\tan \theta}$$

and

$$B = \frac{\frac{\pi}{4} Ll + \frac{h}{\tan \theta} \cdot \lambda}{A}.$$

Let us now proceed to the investigation of M and N.

The dispersion of the shots in the direction of the range depends essentially upon :

1st. The irregularities inherent in the piece itself and in the ammunition (we will indicate by ΔT the probable error due to this cause).

2nd. The probable error due to the aiming, which we will indicate by ΔP.

3rd. The probable error committed in the estimation of the range, which we will indicate by ΔX.

We will thus have

$$M = 2 \sqrt{\Delta T^2 + \Delta P^2 + \Delta X^2}.$$

Let us see how we may determine the three quantities under the radical.

The error ΔT is half the depth of the 50% zone as given in the tables of fire. We must observe, however, that under ordinary circumstances materials and munitions are not in as good condition as they were when the experiments upon which the tables were based, were made. On the other hand, the zones given in the table of fire, combine the errors of piece and gunner, made under the best conditions. At the same time the accuracy of the piece which results from the table of fire, will certainly be considered as a superior limit which in practice will be reached with difficulty.

The error ΔP is only deduced from the tables of fire, when the probable angular error which is committed in giving elevation to the piece is known. The elevation may be accomplished either by causing the prolongation of the line of sight to pass through the target or by adopting a suitable elevation indicator. The errors themselves will necessarily depend on the means employed in aiming and can only be determined by experiment.

The determination of the error ΔX is somewhat more complicated than the preceding.

In order to regulate the fire, we have a range-finder of some system capable of measuring the distance X from the battery to the target with a certain probable error which is a function of this distance and which we will indicate by dX.*

The range corresponding to the elevation given to the piece is composed of two parts; the first, which we denote by y, is the distance of the target when the command *fire* is given: the second, denoted by z, is the space over which the target has approached or withdrawn itself from the battery during the pas-

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* Coast artillery range finders, at least those in use in Italy, belong to the following three distinct types:

1st. Range finders with vertical bases.

Let one of these instruments be placed in a battery at a height H and let $d\epsilon$ be the probable error with which it is capable of measuring the angle ϵ of depression of the target with respect to the battery (fig. 2a).

We will have then

$$dX = \frac{X^2}{H} d\epsilon.$$

2nd. Range finders with horizontal bases.

Such range finders usually have two angle measuring instruments at the extremeties of a fixed base. Let one of these instruments be placed in a battery at A (fig. 3a) and the other at an external station B at a distance D from A.

Let α be the angle BAC and let $d\alpha$ be the probable error with which the two instruments can measure the angles A and B respectively.

We will have then

$$dX = \sqrt{\frac{X^2 (X - D\cos\alpha)^2 + (X^2 + D^2 - 2DX\cos\alpha)^2}{D^2 \sin^2 \alpha}} . d\alpha.$$

If D is very small as compared with X, we may write with sufficient accuracy

$$dX = \frac{X^2 \sqrt{2}}{D \sin \alpha} d\alpha,$$

or better

$$dX = \frac{X \sqrt{2}}{\sin \gamma} d\alpha,$$

in which γ = angle ACB.

3rd. External range finders, consisting of double zenith and azimuth angle measuring instruments.

Let A (fig. 4a) be the position of the battery, and B, at a height H and distance D from the battery, the position of the instrument. The point C represents the position of the target.

Then, $d\alpha$ and $d\epsilon$ being the probable errors with which the instrument is capable of measuring the horizontal and vertical angles respectively we obtain

$$dX = \sqrt{\frac{D^2 \sin^2 \alpha (X - D\cos\alpha)^2 + (X - D\cos\alpha)^4}{H_1^2} d\epsilon^2 + D^2 \sin^2 \alpha \, d\alpha^2}.$$

This, may, with sufficient accuracy, be written

$$dX = \frac{X_1^2}{H_1} \cos \gamma \, d\epsilon$$

and in the majority of cases may be still further simplified, thus:

$$dX = \frac{X_1^2}{H_1} d\epsilon.$$

The quantities $d\epsilon$ and $d\alpha$ must be determined by experiment to be deserving o faith in all cases.

sage of the projectile from the gun to the target, including in this time the few instants necessary to transmit and execute the command "fire."

We thus have

$$X = y \pm z.$$

If we determine y and z separately by committing the errors dy and dz we will have

$$\triangle X = \sqrt{dy^2 + dz^2}.$$

The distance y may be determined by a single observation with the range finder, and the error dy is afterwards calculated by the formula specially determined for the particular range finder used.

We may thus assume $dy = dx$.

To determine the quantity z, the rational procedure, from which all those generally adopted differ only in the mode of execution, is as follows: we measure the distance to the target at a certain instant and then again after t seconds; let y_1 and y_2 be the results of the two measurements, then if the time of flight (increased by the time necessary to command and fire) is τ seconds we have

$$z = \frac{y_1 - y_2}{t} \tau.$$

The value of z thus calculated will be affected by an error dz resulting from those committed in the measurement of the four quantities y_1, y_2, t and τ.

We will denote these errors by dy_1, dy_2, dt and $d\tau$, respectively.

The errors dy_1 and dy_2 depend on the range finder, that of dt upon the observer, who may not execute the measurement of y_1 and y_2 at the precise instant signaled, so that the time which elapses between the two observations will not be exactly t seconds, and that of $d\tau$ upon the variation of the interval of time necessary to command and execute the firing.

Each of the errors dy_1, dy_2, dt, $d\tau$, considered alone has, in the value of z, an error equal to

$$\frac{dz}{dy_1} dy_2 = \frac{\tau}{t} dy_1.$$

$$\frac{dz}{dy_2} dy_2 = - \frac{\tau}{t} dy_2.$$

$$\frac{dz}{dt} dt = \frac{(y_2 - y_1)}{t_2} \tau dt.$$

$$\frac{dz}{d\tau} d\tau = \frac{y_1 - y_2}{t} d\tau.$$

Consequently we will have

$$dz = \sqrt{\left(\frac{\tau}{t}\right) dy_1^2 + \left(\frac{\tau}{t}\right)^2 dy_2^2 + \left(\frac{\tau}{t^2}\right)^2 (y_1 - y_2)^2 \, dt^2 + \frac{(y_1 - y_2)^2}{t^2} d\tau^2}.$$

Since y_1 and y_2 approximate very closely to x, we may place $dy_1 = dy_2 = dx$; also, assuming v to be the component of the velocity of the target in the direction of the fire we have

$$\frac{y_1 - y_2}{t} = v_1.$$

Substituting dx for dy_1 and dy_2 and v_1 for $\frac{y_1 - y_2}{t}$ in the above expression for dz we obtain

$$dz = \sqrt{2 \frac{\tau^2}{t^2} \, dx^2 + v_1^2 \left(\frac{\tau^2}{t^2} \, dt^2 + d\tau^2\right)}.$$

With a careful operator at the range finder and with reliable assistants at the battery; dt and $d\tau$ will be so small that the second term under the radical may almost always be considered as negligible and the expression then becomes

$$\left[dz = \frac{\tau}{t} \sqrt{2 \, dx^2}\right]$$

$$dz = \frac{\tau}{t} \sqrt{2} \, dx.$$

Substituting, finally, this value of dz in the expression for $\triangle X$ we obtain

$$\triangle X = dx \sqrt{1 + 2 \frac{\tau^2}{t^2}}.$$

The dispersion of the shots in a lateral direction is produced:

1st. By the inherent error in the piece which we will indicate by $\triangle_1 T$.

2nd. By the error of the gunner $\triangle_1 P$.

3rd. By the error $\triangle_1 S$, committed in the calculation of the space passed over by the target, during the flight of the projectile, in a direction normal to the plane of fire.

We will thus have

$$N = 2 \sqrt{\triangle_1 T^2 + \triangle_1 P^2 + \triangle_1 S^2}.$$

The probable error $\triangle_1 T$ is half the width of the 50% zone and is found in the table of fire.

The probable error $\triangle_1 P$ is evidently $X da$, X being the distance to the target and da the probable angular error, made laterally, from the direction given to the piece.

This error depends upon the means of aiming employed.

To calculate the space S passed over by the target during flight, normal to the direction of fire, we follow a method analogous to that pointed out for determining the displacement z in the direction of fire.

In the range finding station, there is always found an azimuth instrument, either attached to the range finder directly or independent of it.

Let $d\alpha$ be the probable angular error which an observer using this instrument makes in measuring the angle α, which a direct sight from the station to the target makes with any other direction whatever.* Let α_1 be this angle at a certain instant and α_2 its value after t seconds. The angular displacement $\alpha_1 - \alpha_2$ will evidently correspond to a linear one of $(\alpha_1 - \alpha_2)$ X, so that for the time τ we will have

$$S = \frac{\alpha_1 - \alpha_2}{t} X\tau.$$

Proceeding in the same manner that we did to obtain dz we obtain

$$\Delta S = d\alpha X \frac{\tau}{t} \sqrt{2}.$$

We thus have all the data that we require for the solution of the proposed problem.

To sum up—the per cent of shots upon which we may rely in firing against a vessel in motion is given by the expression

$$\frac{1}{100} P\left(\frac{A}{M}\right) P\left(\frac{B}{N}\right).$$

In which

$$A = \frac{Ll}{\lambda} + \frac{h}{\tan\theta}.$$

$$B = \frac{\frac{\tau}{4} Ll + \frac{h}{\tan\theta}\lambda}{A}$$

In which

$$\lambda = \sqrt{l^2 \cos^2 \varphi + L^2 \sin^2 \varphi}.$$

$$M = 2\sqrt{\Delta T^2 + \Delta P^2 + \Delta X^2}$$

$$\Delta X = dX\sqrt{1 + 2\frac{\tau^2}{t^2}}$$

---

* In the case of a range finder at the battery, the error $d\alpha$ depends simply upon the instrument and upon the observer and is always the same; for a range finder external to the battery we have, instead:

$$d\alpha = \sqrt{\frac{(X - D\cos\alpha)^2 D^2 \sin^2\alpha + D^4 \sin^4\alpha}{X^2 H_1^2} d\epsilon^2 + \frac{(X - D\cos\alpha)^2 d\alpha^2}{X^2}}$$

the notation adopted is the same as that in note page 305.

$$N = 2\sqrt{\overline{\Delta_1 T^2} + \overline{\Delta_1 P^2} + \overline{\Delta S^2}}.$$

$$\Delta S = da \, X \, \frac{\tau}{t} \sqrt{2}.$$

To illustrate the steps of the calculations and in order to give an idea of the results which may be attained with the methods and formulæ developed above, we have determined the probability of fire for various distances of a 24 G. R. C., short, rifle (fired at Grenada) situated in a battery at a height of 100 m., and of a 28 G. R. C. howitzer situated in a battery at a height of 191 m.

Let us suppose

1st. That the probable angular error of aiming in elevation is 2′ for the rifle and 3′ for the howitzer (for the latter, such an error produces an almost negligible influence).

2nd. That the probable lateral error is 2′ for both pieces.

3rd. That, in order to determine the distance, we have at the battery a vertical base range finder, capable of measuring vertical angles with a probable error $d\varepsilon = 0.0001$ (about 20″) and horizontal angles with a probable error $da = .0002$.

4th. That 10″ are required to measure the components of the velocity of the target and 2″ to command and execute the fire.

5th. That the vessel against which the fire is directed has the following dimensions: $L = 100$ m. $l = 20$ m. $h = 5$ m.

6th. That the angle ψ (angle between the axis of the vessel and the plane of fire) has successively values from 0° to 90°.

The results of the calculations are given in the following tables:

24 G. R. C. (short) rifle, H = 100.

TABLE I. Values of A (depth of target).

Distances.	VALUES OF ψ.							
	0°	10°	15°	20°	30°	45°	60°	90°
1000	138	114	100	89	76	66	61	58
1500	142	118	104	93	80	70	65	62
2000	141	117	103	92	78	68	64	61
2500	136	112	98	87	74	64	59	56
3000	130	107	92	82	68	58	53	50
3500	126	102	88	77	64	54	49	46
4000	122	98	84	73	60	50	45	42
5000	117	93	79	68	54	44	40	37
6000	113	89	78	64	51	41	36	33
7000	110	87	72	62	48	38	34	30
8000	108	84	70	59	46	36	31	28
9000	109	82	68	57	44	34	29	26

24 G. R. C. (short) rifle, $H = 100$.

TABLE II. Values of B (breadth of target.)

Distances.	VALUES OF ψ.							
	0°	10°	15°	20°	30°	45°	60°	90°
1000	17	23	28	34	47	65	80	92
1500	17	23	28	35	48	66	80	93
2000	17	23	28	35	48	67	80	93
2500	17	23	28	34	47	66	79	92
3000	17	22	28	34	47	65	79	91
3500	17	22	27	34	46	64	78	90
4000	16	22	27	33	45	63	77	89
5000	16	21	27	32	45	62	76	88
6000	16	21	26	32	44	61	75	87
7000	16	21	26	32	44	60	74	85
8000	16	21	26	32	43	60	73	84
9000	16	21	26	32	43	59	72	83

24 G. R. C. (short) rifle, $H = 100$.

TABLE III. Values of M (depth of the 50 % zone).

X	dX	$\frac{r}{t}$	$\frac{r^2}{t^2}$	$1 + 2\frac{r}{t^2}$	$\overline{\Delta X^2}$	$\overline{\Delta T^2}$	$\overline{\Delta P^2}$	M
1000	1	0.44	0.1936	1.3872	1.50	20	21	13
1500	2.25	0.57	0.3249	1.6498	8.35	49	58	21
2000	4	0.71	0.5041	2.0082	32	90	95	29
2500	6.25	0.86	0.7396	2.4792	97	144	114	38
3000	9	1.02	1.0404	3.0808	249	210	120	48
3500	12.25	1.18	1.3924	3.7848	568	306	121	63
4000	16	1.35	1.8225	4.6450	1189	420	114	83
5000	25	1.72	2.9584	6.9168	4323	576	100	141
6000	36	2.12	4·4944	9.9888	12945	784	81	235
7000	49	2.57	6.6049	14.2098	34118	1056	64	376
8000	64	3.10	9.6100	20.2200	82821	1406	36	580
9000	81	3 75	14.0625	29.1250	191089	1806	25	878

24 G. R. C. (short) rifle, $H = 100$.

TABLE IV. Values of N (breadth of the 50 % zone).

X	$\frac{r}{t}$	2 $\alpha^2 X^2$	ΔS^2	$\overline{\Delta_1 T^2}$	$\overline{\Delta_1 P^2}$	N
1000	0.1936	0.08	0.015	0.02	0.36	1
1500	0.3249	0.18	0.058	0.04	0.71	2
2000	0.5041	0.32	0.16	0.12	1.44	3
2500	0.7396	0.50	0.37	0.36	2.25	3
3000	1.0404	0.72	0.75	0.72	3.24	4
3500	1.3924	0.98	1.36	1.21	4.41	5
4000	1.8225	1 28	2.33	1.96	5.76	6
5000	2.9584	2.00	5.92	4	9.	9
6000	4.4944	2.88	12.93	7.29	12.96	12
7000	6.6049	3.92	25.87	12.96	17.64	15
8000	9.6100	5.12	49 20	21.16	23.04	19
9000	14.0625	6.48	91.11	31.38	29.16	25

24 G. R. C. (short) rifle, H = 100.

TABLE V. Per cent of useful shots.

X	VALUES OF ϕ.							
	0°	10°	15°	20°	30°	45°	60°	90°
1000	100	100	100	100	100	100	100	100
1500	100	100	100	100	99	97.5	96	95
2000	100	97	98	97	93	88.5	86.5	84.5
2500	98.5	95	92	88	81	74	70	68
3000	92	87	80.5	75	66	59	54	52
3500	80	72.5	65	59	50.5	43.5	40	37.5
4000	62	56	50.5	45	37	31.5	28.5	27
5000	33	31	28	25	20	16.5	15	14
6000	16.5	15.5	15	13.5	11	9	8	7.5
7000	8	8	7.5	7	6.5	5.5	5	4.5
8000	4.5	4	4	4	4	3	2.5	2.5
9000	2	2	2	2	2	1.5	1.5	1.5

28 G. R. C. Howitzer, H = 191.

TABLE I. Values of A (depth of target).

Charge.	X	VALUES OF ϕ.							
		0°	10°	15°	20°	30°	45°	60°	90°
I	900	112	88	74	63	50	40	35	32
	1200	110	86	72	61	48	38	33	30
	1600	109	85	71	60	47	37	32	29
	2150	105	81	67	56	43	33	28	25
II	1300	114	90	76	65	52	42	37	34
	1800	112	88	74	63	50	40	35	32
	2400	109	85	71	60	47	37	32	29
	3050	105	81	67	56	43	33	28	25
III	2500	113	89	75	64	51	41	36	33
	3000	112	88	74	63	50	40	35	32
	3700	109	85	71	60	47	37	32	29
	4650	105	81	67	56	43	33	28	25
IV	3550	113	89	75	64	51	41	36	33
	4000	111	87	73	62	49	39	34	31
	4700	109	85	71	60	47	37	32	29
	5800	105	81	67	56	43	33	28	25
V	4700	112	88	74	63	50	40	35	32
	5400	110	86	72	61	48	38	33	30
	6400	107	83	69	58	45	35	30	27
	7400	104	80	66	55	42	32	27	24
VI	5850	110	86	72	61	48	38	33	30
	6300	109	85	71	60	47	37	32	29
	7100	106	82	68	57	44	34	28	26
	7950	104	80	66	55	42	32	27	24

28 G. R. C. Howitzer, H = 191.

TABLE II. Values of B (breadth of target.)

Charge.	X	VALUES OF ψ.							
		0°	10°	15°	20°	30°	45°	60°	90°
I	900	16	21.5	26.5	32	44	61	75	86.5
	1200	16	21	26	32	44	60	74	85.5
	1600	16	21	26	32	43.5	60	73.5	85
	2150	16	21	26	31	43	58.5	71.5	82
II	1300	16	21.5	26.5	32.5	44.5	61	75	87
	1800	16	21.5	26.5	32	44	61	75	86.5
	2400	16	21	26	32	43.5	60	73.5	85
	3050	16	21	26	31	43	58.5	71.5	82
III	2500	16	21.5	26.5	32	44	61	75	86.5
	3000	16	21.5	26.5	32	44	61	75	86.5
	3700	16	21	26	32	43.5	60	73.5	85
	4650	16	21	26	31	43	58.5	71.5	82
IV	3550	16	21.5	26.5	32	44	61	75	86.5
	4000	16	21	26	32	44	60.5	74.5	86
	4700	16	21	26	32	43.5	60	73.5	85
	5800	16	21	26	31	43	58.5	71.5	82
V	4700	16	21.5	26.5	32	44	61	75	86.5
	5400	16	21	26	32	44	60	74	85.5
	6400	16	21	26	32	43	59	73	84
	7400	16	21	26	31	42.5	58	71	82
VI	5850	16	21	26	32	44	60	74	85.5
	6300	16	21	26	32	43.5	60	73.5	85
	7100	16	21	26	31.5	43	59	72	83.5
	7950	16	21	26	31	42.5	58	71	82

28 G. R. C. Howitzer, H = 191.

TABLE III. Values of M (depth of the 50 % zone).

Charge.	X	ΔX	$\frac{\tau}{t}$	$\frac{\tau^2}{t^2}$	$1 + 2\frac{\tau^2}{t^2}$	$\overline{\Delta X^2}$	$\overline{\Delta T^2}$	ΔP^2	M
I	900	0.44	0.84	0.71	2.42	0.47	6	9	8
	1200	0.77	1.07	1.14	3.28	1.94	30	6	12
	1600	1.37	1.42	2.02	5.04	9.45	70	6	19
	2150	2.45	2.09	4.37	9.74	58.46	169	0.25	30
II	1300	0.90	0.97	0.94	2.88	2.33	4	16	9
	1800	1.72	1.29	1.66	4.32	12.79	16	16	13
	2400	3.05	1.75	3.06	7.12	66.20	72	12	24
	3050	4.91	2.60	6.76	14.52	349.93	182	0.25	46
III	2500	3.31	1.41	1.99	4.98	54.58	30	36	22
	3000	4.76	1.68	2.82	6.64	150.46	64	30	31
	3700	7.22	2.11	4.45	9.90	516.09	169	25	53
	4650	11.38	3.11	9.67	20.34	2643 38	324	2	109
IV	3550	6.65	1.75	3.06	7.12	315	110	56	44
	4000	8.44	1.09	3.06	8.92	635	156	49	58
	4700	11.63	2.40	5.76	12.52	1685	240	36	88
	5800	17.70	3.57	12.74	26.48	8296	441	4	187

TABLE III. (Continued).

Charge.	X	ΔX	$\frac{r}{t}$	$\frac{r^2}{t^2}$	$1 + 2\frac{r^2}{t^2}$	$\overline{\Delta X^2}$	$\overline{\Delta_1 T^2}$	$\overline{\Delta P^2}$	M
V	4700	11.63	2.02	4.08	9.16	1233	196	81	78
	5400	15.35	2.38	5.66	12.32	2884	289	72	114
	6400	21.55	2.99	8.94	18.88	8727	420	42	192
	7400	28.82	4.19	17.56	36.12	29959	600	0.25	350
VI	5850	18.01	2.47	6.10	13.20	4277	324	81	137
	6300	20.89	2.71	7.34	15.68	6850	400	73	171
	7100	26.53	3.24	10.50	22.00	15449	529	36	254
	7950	33.26	4.15	17.22	35.44	39299	650	1	400

28 G. R. C. Howitzer, H = 191.

TABLE IV. Values of N (breadth of the 50 % zone).

Charge.	X	$\frac{r^2}{t^2}$	$\overline{2\Delta\alpha^2 X^2}$	$\overline{\Delta S^2}$	$\overline{\Delta_1 T^2}$	$\overline{\Delta P^2}$	N
I	900	0.71	0.06	0.04	1	0.29	2.3
	1200	1.14	0.11	0.12	1	0.52	2.5
	1600	2.02	0.20	0.40	2	0.92	3.5
	2150	4.37	0.37	1.62	4	1.66	5.5
II	1300	0.94	0.13	0.12	1	0.60	2.5
	1800	1.66	0.26	0.43	2	1.17	4
	2400	3.06	0.46	1.41	4	2.07	5.5
	3050	6.76	0.74	5.00	9	3.35	8.5
III	2500	1.99	0.50	0.99	6	2.25	5.5
	3000	2.82	0.72	2.03	4	3.24	6.5
	3700	4.45	1.09	4.85	12	4.93	9.5
	4650	9.67	1.73	16.73	20	7.78	13.5
IV	3550	3.06	1.01	3.09	9	4.53	8
	4000	3.96	1.28	5.07	12	5.76	9.5
	4700	5.76	1.77	10.19	20	7.95	12.5
	5800	12.74	2.69	34.27	40	12.11	18.5
V	4700	4.08	1.77	7.22	12	7.95	10.5
	5400	5.66	2.09	11.83	16	9.42	12
	6400	8.94	3.28	29.32	25	14.75	16.5
	7400	17.56	4.38	76.91	49	19.71	24
VI	5850	6.10	2.74	16.71	30	12.32	15.5
	6300	7.34	3.17	23.27	36	14.28	17
	7100	10.50	4.03	42.31	56	18.15	21.5
	7950	17.22	5.06	87.13	90	22.75	28

28 G. R. C. Howitzer, H = 191.

TABLE V. Per cent of useful shots.

Charge.	X	VALUES OF ψ.						
		0°	15°	20°	30°	45°	60°	90°
I	900	100	100	100	100	100	100	99.5
	1200	100	100	100	99.5	97	94	90
	1600	100	99	97	90	81	74	69
	2150	93	87	79	66	54	47	42.5
II	1300	100	100	100	100	100	99.5	99
	1800	99.5	100	100	99	96	93	90
	2400	95	95.5	91	81.5	70	63	59
	3050	70	64.5	58	47	37	32	28.5
III	2500	95	98	95	88	79	73	68.5
	3000	88.5	88	83	72	62	55.5	51.5
	3700	61.5	59	54	45	36	31.5	29
	4650	27.5	26	24	20	16	13.5	12.5
IV	3550	76	73	66.5	57	47	42	38.5
	4000	59	61	51.5	43	35	30.5	28
	4700	36.5	35	32	27.5	22.5	19	17.5
	5800	13	12.5	12	11	9	8	7
V	4700	45.5	43.5	40	33.5	27	24	22
	5400	30	28.5	26	22	17.5	15.5	14
	6400	14	13.5	13	11.5	10	8	7.5
	7400	5	5.5	5	5	4.5	4.5	4
VI	5850	21	20.5	19	17.5	15	13	12
	6300	16	15.5	14.5	13.5	11.5	10	9
	7100	8.5	8.5	8	7.5	6.5	6	5.5
	7950	4	4	4	4.5	4	35.	3

With distances as abscissas and probability per cent as ordinates (Table V), various curves may be traced corresponding to different values of ψ which will give the probability of fire for any distance whatever. For howitzers, on account of the variation of the charges, we will have, instead of a single curve, a bundle of curves, which will be partly superimposed and partly continuations of each other. For simplicity, a single curve, which is the mean of the whole bundle, will be substituted for it.

Between what limits will the angle ψ be practically comprised? This depends upon a number of tactical and technical circumstances and will vary accordingly. We will assume, however, that it may vary with equal probability from 0° to 90°.

A curve may now be traced which will represent for any range whatever, the mean probability of all those which are inherent to the various possible values of ψ.

Again, by laying off the different values of ψ as abscissas and the corresponding values of the probability as ordinates, we may, either from the data contained in table V, or by the transformation of the curves in figs. 6a and 7a obtain those of figs. 8a and 9a, each of which represents the probability of fire for a given range when the angle ψ varies from 0° to 90°.

By means of Simpson's quadrature formula we can calculate the altitude of the equivalent retangle, that is, the altitude of the retangle whose area is equal to the area contained between the curve, its axes and the extreme ordinates corresponding to $\psi = 90°$.

This altitude will represent the mean probability for the range corresponding to the curve considered. We thus obtain the elements for tracing the curve of figure 10a.

The discussion of the above formulae and their application to the varied conditions which may be met with in practice, leads as was said in the beginning, to results which are important tactically as well as technically. We will now call attention to same of these deductions as a corollary to what has already been deduced.

The elements which show the total offensive value which a battery or group of batteries may acquire over a given zone, are essentially: the number of pieces which fight that zone, their celerity of fire, the importance of the effect of their shots and the proportion of the useful shots upon which reliance may be placed.

This last element has certainly an importance equal to that of the others and furnishes abstractions which may lead to dangerous illusions.

On the other hand, in connection with the results obtained with the above formulas, we believe it necessary to repeat what was stated in the beginning, namely, that these results represent only a superior limit to which we may approximate whenever we realize a combination of the most favorable circumstances.

In order to really attain these results, it is supposed:

1st. That the firing is constantly corrected, but, as has already been pointed out, this hypothesis will be admissible only at intervals and even then with greater or less approximation.

2nd. That the route of the target can be predicted; we believe that this hypothesis will be quite frequently verified; if, however, it is not verified, or so to speak, is only verified at intervals of greater and less length depending upon the liberty of maneuvre which the tactital and hydrographical circumstances and the object to be obtained, leave to the target, the probability of fire may be found notably reduced.*

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* A vessel free in its movements may give rise to a large number of varied cases, to which correspond different probabilities. It is not intended to examine them here nor even to attempt a more or less synthetical solution; we observe only, that, calculating a certain

3rd. Finally, that we have considered all the obstructions, all the difficulties, all the errors imputable to the external circumstances, the materiel and especially the personnel, which latter has a preponderating influence upon the success of any fighting, whatever its kind.

In a word, the results which we have found correspond to the hypothesis that everything is conducted in the best and most favorable manner, in all that concerns the target, the external circumstances, the command and the service of the battery.

In order to obtain the per cent of the useful shots upon which we may rely when this does not happen—and it will not happen in the majority of cases—we will have to multiply the results furnished by the calculations by a coefficient of reduction.

It is difficult to determine, a priori, what this coefficient ought to be, since it depends upon a quantity of variable circumstances which it is difficult to subject to calculation. Experiments, too, furnishes few hints, specially worthy of note, because in peace firing we never succeed in reproducing either the technical or tactical conditions of battle fire. Nevertheless, a certain experience in firing and the synthetical study of the various causes of error which influence it, may lead to the formulation of some included creterion, whose accuracy may certainly be open to discussion but which may yet be adopted for lack of more certain elements.

In my opinion, when considering firing executed under conditions neither excessively favorable nor yet too unfavorable, this coefficient of reduction may be taken to lie between ¾ and ½; the former being nearer for cannon, the latter for howitzer. This, however, is an exclusively personal approximation.

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number of examples whose data of departure are so chosen as to depend upon the kind and upon the particular conditions of the fighting expected, we will obtain sufficient criteria to determine the probability of fire for the cases which deviate from those considered as normal. To solve these problems the method to be pursued is that adopted in the calculation of the probability of non-centered fire.

As an example chosen from those most unfavorable, let us assume a vessel, of the type already considered to be passing over the path M N (fig. 11a) with a velocity of 5 *m.* per second (about [illegible] knots). [illegible] B is a battery of 28 G. R. C. howitzers (H = 191). When the vessel reaches A a salvo is fired from the battery; at the same instant, the vessel changes direction, describing the arc A Q assumed to be a circle with a radius of say 200 m. (We note that in order that this most unfavorable case occur, the helms must have been pushed to one side [illegible] seconds earlier).

We will suppose moreover though it is not necessarily true, that the velocity of the vessel remains unaltered and that its axis (middle point) is always tangent to the curve of evolution (Concerning the movement of vessels under the action of the helm, see White's *Manual of Naval Architecture*, also Guyon's *Théorie du navire*.

If the vessel had continued its route till the projectile had terminated its trajectory, it would have reached a certain point O which would have been the center of impact. Let us suppose B O = [illegible] m.; the time of flight increased by 2 seconds, being then 24 seconds (Table No. IV) the distance A O is 120 m. Assume B O M = 60°. Due to the change of direction the vessel will be at Q instead of at O at the end of the 24 seconds. The coordinates of Q referred to M N and Y Y' are x = [illegible] and y = 35 m. The angle ψ made by the axis of the vessel with the plane of fire is about 50°, and to this angle corresponds a depth of target A = [illegible] m. and a width B = [illegible] m. By means of these data and that furnished by the tables III and IV we find the per cent of the useful shots to be 17.2, which is equal to that which would have been obtained had the vessel continued the initial route.

If the point B were on the prolongation of M N we would have ψ = 34°, A = 44 m. and B = [illegible] m. and the resulting [illegible] would be 3.

From the results which we have obtained, we should deduce that the probability of fire is independent of the velocity of the target—a deduction verified with difficulty in practice.

We observe, indeed:

1st. That the greater the velocity of the target, the greater is the difficulty of keeping the fire corrected.

2nd. That to greater velocities must correspond greater errors in the manipulation of the range finders and in the aiming, especially when the latter is accomplished by directing the line of sight upon the target.

3rd. That by increasing the velocity, we increase various small errors, already discussed, the sum total of which might, under certain circumstances, no longer be negligible, but would certainly increase the errors due to the difficulties and inevitable delays, even with the best instructed personnel.

In practice, for all these reasons, a somewhat smaller probability ought to correspond to the greater velocities and consequently a smaller coefficient of reduction than that indicated above.

We have deduced the formula:

$$M = 2\sqrt{\overline{\Delta T}^2 + \overline{\Delta P}^2 + \overline{\Delta X}^2}$$

in which

$$\Delta X = dX\sqrt{1 + 2\frac{\tau^2}{t^2}},$$

and the other one:

$$N = 2\sqrt{\overline{\Delta_1 T}^2 + \overline{\Delta_1 P}^2 + \Delta S^2},$$

in which

$$\Delta S = d\alpha\, X\frac{\tau}{t}\sqrt{2}\ .$$

These formulas show the inaccuracy of the oft repeated affirmation that almost as many hits are made against a moveable target as against a stationary one.

An affirmation, so general, is perhaps not intended by those even who make it. Against a stationary target the firing may always be corrected after a few shots; there is no concern about the inherent error of the range finder, nor the irregular movement of the target—conditions certainly not avoided under any other circumstances. I maintain, rather. that this expression only signifies that, when the conditions assumed in the preparation for firing are verified, we eliminate, by this means, completely, the error due to the displacement of the target from the instant in which the distance to it is measured to that in which the projectile completes its trajectory.

To this conception correspond the formulas

$$M = {}^2\sqrt{\Delta T^2 + \Delta P^2 + \Delta X^2}$$

and

$$N = {}^2\sqrt{\Delta_1 T^2 + \Delta_1 P^2}.$$

These formulas with a change in symbols have also been adopted by Lieutenant Calichiopulo.

But as Captain Rivals says, if the range finder is not accurate (and it is never absolutely so), when we determine the correction to be applied to the data of firing to compensate for the displacement of the target, we commit a new error which is of the same order as that due to the range finder and increases the error committed in the measurement of the range by diminishing further the precision of the firing.

The methods which we have developed and the formulae which we have deduced are but the analytical development of this conception.

The use of the formula corresponding to the hypothesis relating to the stationary target leads, quite naturally, to results which are found to be mainly errors in excess especially for the greater distances (see figs. 12a and 13a).

Among the various quantities upon which the value of M. depends, that which increases most rapidly with an increase in the distance and which therefore has the greatest influence in diminishing the per cent of useful shots, is the error proceeding from the operation of the range finder or ΔX. Let us see under what conditions this error has the least value and consequently corresponds to the greatest probability of fire.

We have found

$$\Delta X = dX\sqrt{1 + 2\frac{\tau^2}{t^2}}.$$

A simple glance at this formula shows:

1st. That ΔX diminishes with dX, i. e., with the error of the range finder: if, for example, the adopted range finder has a vertical base, we have

$$dX = \frac{X^2}{H}\,d\varepsilon;$$

ΔX diminishes, therefore, as the height of the battery increases and as d diminishes. In figures 14a and 15a are traced probability curves for the 24 G. R. C. short cannon situated at heights above the level of the sea of 50 m. and 100 m., and for the 28 G. R. C. howitzer situated at heights of 50, 191 and 666 m's., by assuming in each case that the probable angular error of the adopted range finder is

$$d\varepsilon = 0.0001.$$

Identical results would be obtained by assuming we had two 24 G. R. C. short cannon, at a height of 100 m. the probable range finder error being $d\varepsilon = 0.0002$, and three 28 G. R. C. howitzers at a height of 191 m., the probable range finder error being, respectively, $d\varepsilon = 0.0001 \left(\frac{191}{50}\right)$, $d\varepsilon = 0.0001$, and $d\varepsilon = 0.0001 \left(\frac{191}{666}\right)$. (See figures 14a and 15a).

Hence we see that an increase in the precision of the range finder may be obtained either by increasing the height of the station or by perfecting the instrument, or the same result may be obtained by increasing the number of pieces.

2nd. ΔX increases or diminishes as the time of flight τ increases or diminishes. This is one of the causes, though not always the most important, on account of which a greater probability of fire ought to correspond to a greater initial velocity and this is realized especially when we compare cannon with mortars, or the same mortar with different charges, when the elevation is less than 45°.

This is also one of the causes on account of which shots from howitzers with elevations less than 45° give greater probabilities than those made with greater elevations (see fig. 16a).

3rd. ΔX increases or diminishes as t diminishes or increases.

In the cases then, in which the per cent of the useful shots tends to diminish through the increase of τ, we may, by way of compension, increase t, provided the movement of the target is such that it permits the protraction of the time of the observation. If, for example, we always take $t = n\tau$, n being any constant whatever, $\gtreqless 1$, we will have $\Delta X = dX\sqrt{1 + \frac{2}{n^2}}$, and the probability of hitting comes out independent of the time of flight.

In practice, the assumption each time, of a different value of t, may present difficulties. Two values of t, as for example 10″ and 20″, may, however, be adopted with considerable advantage, the greater to be used when permitted by the movement of the target or when the value of τ increases beyond certain limits.

Similarly, we might discuss the value of ΔS and obtain conclusions analogous to the preceding though of less importance.

In figures 12a to 18a are shown the effects, upon the probability of the variation of ΔX and ΔS in the manner indicated in the discussion.

[Translated by Second Lieutenant F. E. Harris, First Artillery.]

Fig. 1a

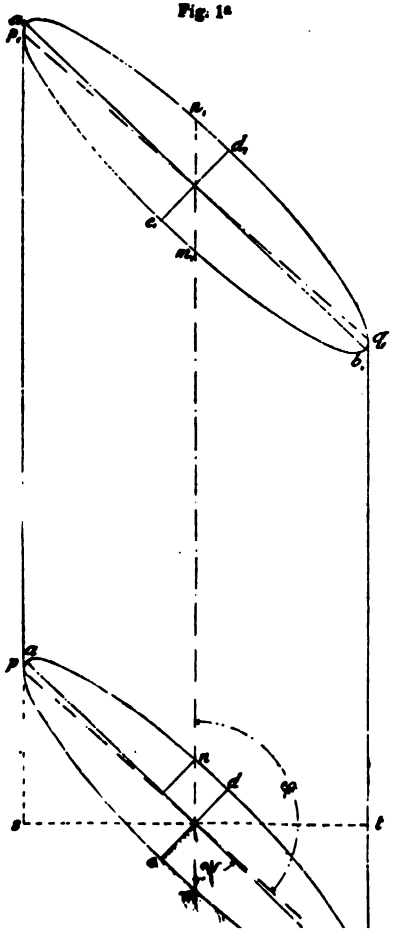


Fig. 2a

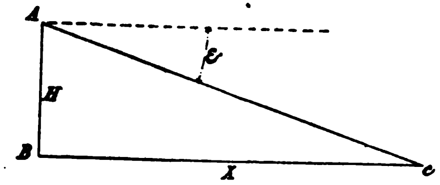


Fig. 3a

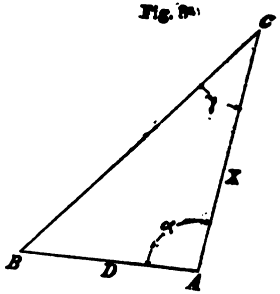


Fig. 4a

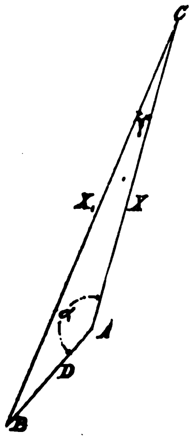
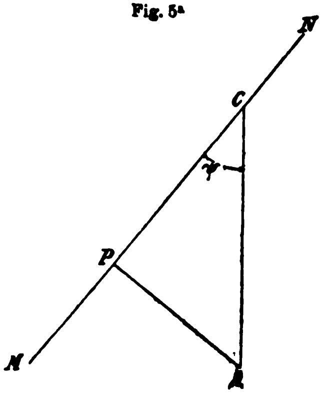


Fig. 5a



CONTRIBUTO ALLO STUDIO DELLE PROBABILITÀ DI TIRO DELLE ARTIGLIERIE DA COSTA

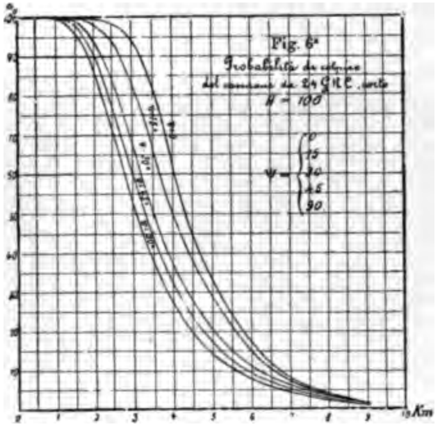


Fig. 6ª

Probabilità di colpire del cannone da 24 G R C, corto
H = 100
Ψ = {0, 15, 30, 45, 90

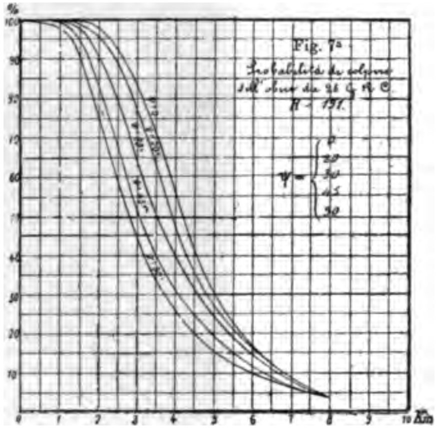


Fig. 7ª

Probabilità di colpire dell'obice da 28 G R C.
H = 151.
Ψ = {0, 20, 30, 45, 90

Fig. 8ª - Cannone da 24 G R C, corto

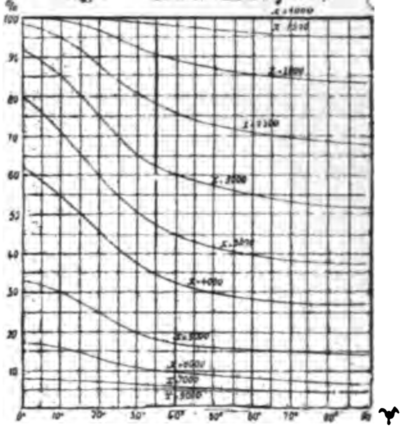
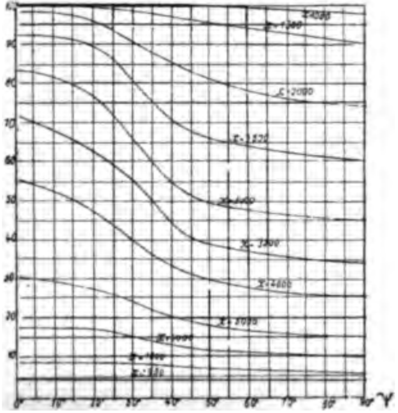


Fig. 9ª - Obice da 28 G R C



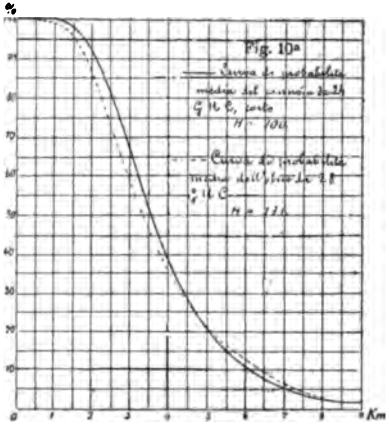
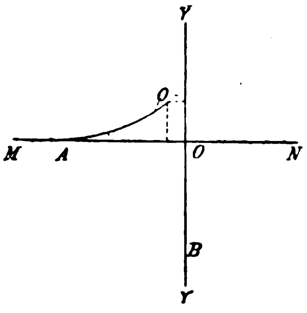


Fig. 10ª

—— Curva di probabilità media del cannone da 24 G R C, corto
H = 100

- - - Curva di probabilità media dell'obice da 28 G R C
H = 151

Fig. 11ª



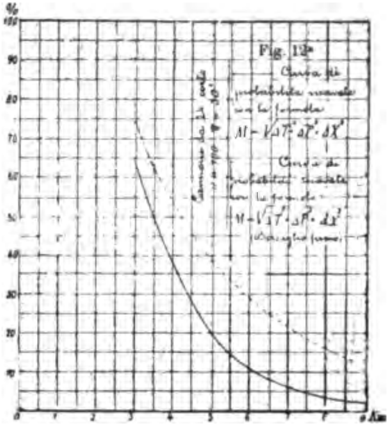


Fig. 12ª

Cannone da 24 corto
H = 100 Ψ = 30°

Curva di probabilità ricavata con la formola
$M = \sqrt{\Delta T^2 + \Delta P^2 + \Delta X^2}$

Curva di probabilità ricavata con la formola
$M = \sqrt{\Delta T^2 + \Delta P^2 + \Delta X^2}$
(Bassi angoli)

Laboratorio foto-litografico del Ministero della Guerra

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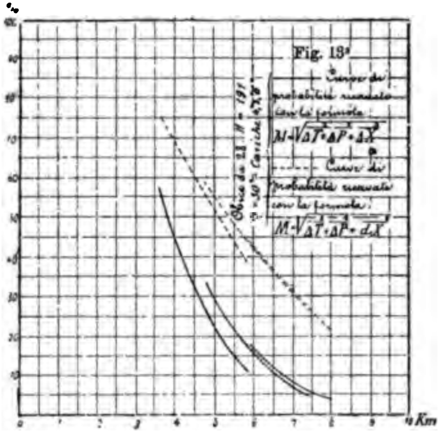
Fig. 13ª

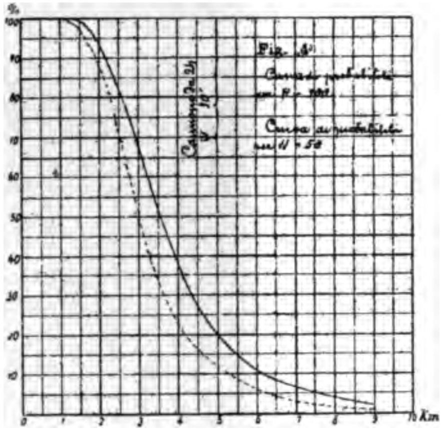
Fig. 14ª

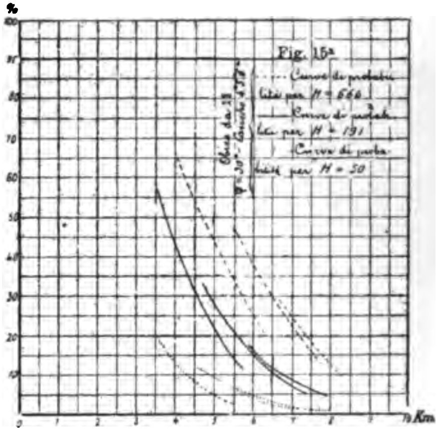
Fig. 15ª

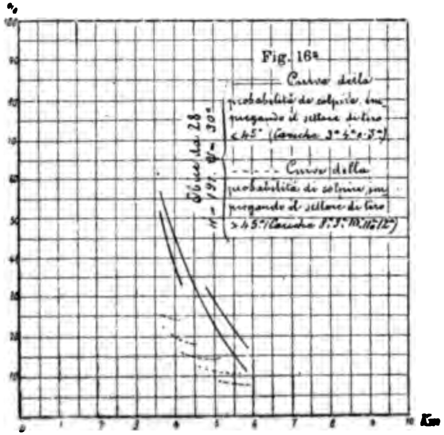
Fig. 16ª

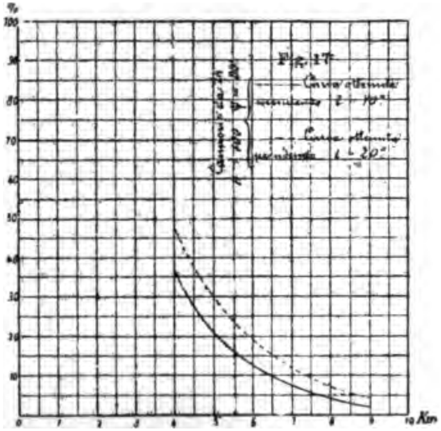
Fig. 17

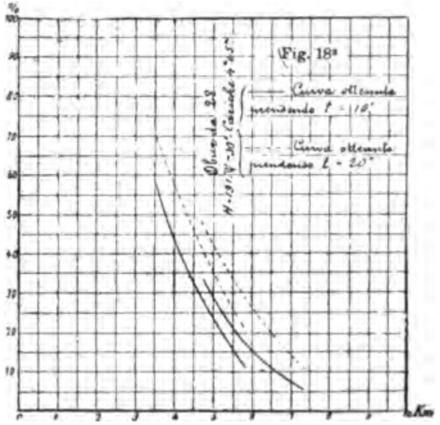
Fig. 18ª

HOWITZERS AND MORTARS FOR FIELD ARTILLERY, TO SUPPLY A NEED OF CURVED FIRE.

By Tiedemann, Major and *Abteilungs-Kommandeur* in the Posen Field Artillery Regiment, No. 29.

Jahrbücher für die deutsche Armee und Marine, November 1897.

V. GERMANY.

It was again proposed in Germany in 1885 and 1886 to introduce a short 12 cm. (4.7") cannon for use in siege warfare in places where shrapnel fired from long cannon did not possess a sufficient angle of fall. It was intended that this howitzer should also be taken into the field for use against intrenchments. But as the need of such a gun in siege warfare was not considered sufficiently demonstrated, there was a return to reduced powder charges, as we have before noted, but the results obtained were exceedingly poor. In the meantime, the military regulations of nearly all nations laid more and more stress on the spade for throwing up hasty intrenchments or even semi-permanent works; and the problem was set for the artillery to drive out intrenched infantry, or effectively cannonade them in their intrenchments. Hence the trial of diminished powder charges was revived in 1888-89; and this time comparative tests were made with the 12 cm. short cannon. This was a cast-steel piece with breech mechanism of the sliding wedge type; the length of the riflebore was 10 calibers. With the breech mechanism the piece weighed 550 kg. (1210 pounds); the service charge was 1 kg. (2.2 pounds) of gunpowder. The carriage of the piece weighed 550 kg. (1210 pounds); and with piece and accessories, 1119 kg. (2,462 pounds). The limber carrying 15 rounds (3 shell and 12 shrapnel) weighed 867 kg. (1907 pounds). Thus the entire weight, as equipped for the field, was 1986 kg. (4369 pounds), and hence was somewhat less than the German field gun. The caisson weighed 2271 kg. (5000 pounds), having 15 rounds in the limber and 36 in the body.

The shell weighed 16.27 kg. (35.8 pounds), the shrapnel with its charge in the base weighed 16.5 kg. (36.3 pounds). The shrapnel contained 557 g. (1¼ pounds) of bursting charge, and from 475 to 480 balls of hardened lead weighing 11.1 g. each.

With shrapnel the maximum range was 4300 m. with 33° elevation.

Extensive trials were made with this howitzer, using various charges, against targets in the open at all ranges; and between 2900 m. and 4300 m., the howitzers were tried in competition with field guns against concealed targets. When using reduced charges, the howitzer proved much the better as regards variation in range and observation of the shot. The firing was continued for a long time, and conducted with great pains, and the short cannon proved decidedly superior, using the reduced charges. Firing the projectiles along flat trajectories, the short cannon made a great number of hits, firing shrapnel when the point of bursting was close to the target. As the distance between point of bursting and target increased, this relation changed in favor of the field gun, as a consequence of the latter having a greater final velocity. The effect of the 12 cm. shrapnel did not extend much further than 100 m. beyond the point of bursting. The artilleries of many countries have abandoned the use of shell against living objects, and their use here in the 12 cm. short cannon was found unsatisfactory. Using both kinds of cannon for curved fire against targets protected against an angle of fall from 15° to 25°, the results were only occasionally good.

The Artillery Commission came to the following conclusion (see Müller, Entwickelung der Feldartillerie, 1870-1892): "The short 12 cm. cannon is not suitable for replacing the heavy field gun in all positions. Undoubtedly it is superior for curved fire, but it is decidedly inferior for a flat trajectory. Hence it has the character of a special gun, and a few of these guns with an army would suffice. To carry reduced charges for field guns would tend to diminish the utility of these guns for their other work."

This decision was rendered towards the end of 1888, and reference was made at the same time to the tests of high explosive shell then in progress, and it was observed that if these tests proved successful, there would be no need of introducing the 12 cm. howitzer, which otherwise might be recommended.

Germany stands alone as the only one of the powers that has finally adopted another method of reaching targets close behind parapets than that of employing mortars or howitzers. A little before the beginning of the year 1890, Germany discarded the light field gun of the horse artillery, and gave to the entire field artillery a simple field gun which met every requirement of rapidity of fire and mobility. The inconveniences attached to using a howitzer or mortar along with a field gun of less caliber were duly weighed, and it was preferred to use the field gun fired at high angles for reaching troops protected against an angle of fall of 22° or even a greater angle.

This last object was also obtained by adopting a shell with a high explosive bursting charge. This projectile, with the same fuze as the shrapnel, scattered its 1000 fragments with so large an angle in the cone of dispersion that concealed targets could thereby be attained. A great advantage was secured in that the method of firing the shell differed little from that of firing shrapnel. Thus unity of caliber and of piece was preserved, as well as uniformity in the service of the piece and in the supply of ammunition. These are indeed real advantages, and cannot easily be overestimated.

Though the resnlts from firing this projectile under service conditions have not always been satisfactory, and unfavorable opinions of its value have at times been expressed, yet this may easily be laid to the fact that the troops must have time to become familiar with a new projectile just as with a new gun. The piece as well as the regulations for its service have undergone improvements.

The editor of *v. Loebell's Jahresberichte* for 1890 expresses himself as follows: "In our opinion the shell fired from the field gun against living objects is at least as effective as the 12 cm. shrapnel from mortars or howitzers. The reports published by Krupp and Gruson of trials with such guns leave no room for doubt on this head. Indeed the shell fired from the field gun can risk comparison with the 15 cm. shrapnel as is shown by the tests at Meppen in August, 1887. Mortars and howitzers having but a very limited application, the shell exempts us from the necessity of taking into the field cannon that serve but a very restricted purpose.

"If, however, in firing against concealed targets further requirements are made, thus, that blindages, etc., be destroyed, the howitzer or mortar then becomes indispensable, but even in such a case they also must use the high explosive shell. They will then clearly surpass the field gun firing shell; this is not due alone to the greater weight of the howitzer and mortar shell, but also to the more favorable form of its trajectory, enabling it to deliver a veritable reverse fire against the objects behind cover. However, as special guns in the field artillery have many drawbacks, we are of opinion that they should not be adopted, until it is demonstrated that the field gun firing shell does not accomplish the purpose."

Too much penetration was at first looked for from the shell's fragments, which, though small, are yet projected with great force. As the penetration proved insufficient, however, the bursting charge was made of a less violent nature, and instead of 1000 pieces on bursting there resulted 500 of from 10 to 13 g. in weight. Better penetration was thus obtained in living targets, but much still remained to be wished for as regards inanimate objects.

If we remember how in the intrenchments of both parties in the American War of Secession, blindages of timber and plank were employed to cover the troops, it must be allowed that the shell with time fuze would not be able to destroy the slightest of these structures, with the small pieces into which it bursts. If the shell had the percussion fuze, it would indeed of itself be sufficient to break through these shelters, but it would fail because the blindages are protected against the angle of fall of the complete projectile when fired from field guns.

A force opposed to a German army would need but to construct light overhead cover in its trenches, and under this the infantry could crowd and remain there until the German infantry in attacking had approached to the critical distance, *i. e.*, to from 300 to 400 meters. Up to this time the fire of the German artillery would have failed against the shelter, and it must now cease firing for fear of hitting its own troops. The infantry of the enemy could now emerge from their cover, and undisturbed by artillery fire, open upon the attacking infantry.

In the case thus supposed howitzers or mortars would be necessary to break through the shelter; they could do this by firing shrapnel with percussion fuze, but better by shell with a high explosive charge. The shrapnel with percussion fuze would penetrate the lighter sort of cover and disable the men within on bursting. As its angle of dispersion is small, not many men would be hit, though such as were would probably receive a good many bullets. This, however, is not important, though generally speaking the object sought is, with a single shot, to render as many of the enemy as possible unable to continue to fight.

The shell would be more effective, especially when its charge of high explosive is a large one. When used with a percussion fuze, the shell would not only penetrate the shelter but would tear it up by the air compression due to its explosion; it will disable the men within by its fragments dispersed under a large angle, and also through the concussion in the air produce serious internal injuries. The shell, therefore, with a heavy charge of a large explosive will undoubtedly be more effective.

When it is a matter of attacking earthworks, the superiority of the shell is much more decided. The effect of shrapnel entering a parapet is very small, even when fired from a mortar or howitzer, while the shell with an interior charge of 6 kg. (13.2 pounds) of melinite (as the French 12 cm. howitzer) will tear out a large section.

Appreciating these facts, Russia and France have introduced the howitzer or mortar into their field artillery, and provided both types of projectiles, the shrapnel and the shell, the latter with a heavier and more violent interior charge.

It might seem, from the above, that shrapnel was superfluous with howitzers and mortars and might be replaced altogether by shell having a heavy charge of high explosive. This, however, is not the case, as the following considerations will show. Overhead cover will not be continuous behind intrenchments, but will occur only in a few places, since time as well as material will be lacking for constructing a considerable amount of such shelter. A comparatively small quantity of shell will be sufficient therefore to destroy these shelters or render them untenable. In spite of the great effect on the nerves of men near where it strikes, the radius of action of the shell is less than that of the shrapnel. So that the shrapnel with time fuze will unquestionably be more effective than the shell when used against troops sitting close to the interior slope, but without overhead cover. This will be especially the case when the intrenchments are not components of a fortress group, but are simply rifle pits on the battle-field or trenches to shelter supports and reserves.

The editor of *v. Loebell's Jahresberichte* for 1893 is also of opinion that shell fired from the German field gun is insufficient for attacking the lightest blindages. He is of opinion that for this purpose cannon with vertical fire, as mortars and howitzers, are requisite.

Two years later he writes: "It is more and more growing to be a general opinion, based on proving-ground tests, that shell fired from field guns are of questionable value for attacking troops behind intrenchments when the men sit close to the parapet. To reach such a target requires a precision in firing and a nicety of observation that can rarely be attained in war."

We do not entirely agree with this judgment. Precise firing and nice observation are necessary in mortar and howitzer firing if good results are desired. Nor is it quite right to say shell are of questionable value; the most we can say is that shell is not as sure as shrapnel. In firing shell from the field gun with due care the results may prove right good, and again may be almost nil.

The reason for this is that on account of the large angle of the cone of dispersion and the flat trajectory of the field gun, only the under part of the cylinder of the projectile, making about 125 or 150 fragments, have any chance of being effective against targets close behind a parapet. The part of the projectile that is uppermost at the time of bursting as well as the pieces ricocheting from the ground will be harmless against such targets.

The angle of the cone under which the 500 or so fragments weighing 10 to 13 g. are scattered is equal to about 110°. With shrapnel the sheaf is almost evenly filled, as the final velocity of the projectile exceeds that of the bursting charge; but with the high explosive shell the cone is always hollow, the angle of the inner hollow cone being estimated at about 90°.

In regard to the effect of the shell General Rohne, in his "*Schiesslehre für die Feldartillerie*," writes as follows: "A target close behind a shelter which protects it against an angle of fall, α, can only be hit when the point of bursting of the projectile lies above the right line BZ (see fig. 1), which is inclined at an angle α with the horizontal. The very least cover that a parapet in the field offers is about 22°. Since the cotangent of 22° is approximately 2.5. only such projectiles can be expected to be effective the height of whose point of burst above the interior crest is more than 2½ as great as the horizontal distance between the point of burst and the crest.

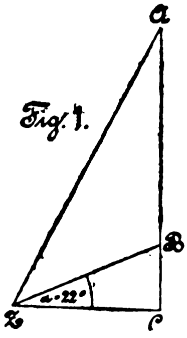
Fig. 1.

The greatest angle that a fragment will have, will be equal to the sum of half the angle of the cone (55°) plus the angle of fall. At 2000 meters this sum will be about 61°, at 3000 m. about 67°, at the chief fighting ranges it will average about 64°. A projectile will have no effect whatever if its point of bursting lies above the line AZ, which is inclined at an angle equal to the steepest angle of fall of any fragment, for in this case all the pieces must pass over the target. As the cotangent of 64° is approximately 0.5. it follows that to be effective, the horizontal distance between the interior crest and point of bursting must be greater than half the difference in their vertical height.

Only projectiles bursting in the angle AZB can be effective, and these must not burst too far to the front. If they do the fragments will lose too much in velocity and will be too widely scattered.

For a light fragment (10 g.) to make a serious hit the final velocity must not fall below 150 m. (492 feet); with this velocity the heavier fragments would probably penetrate light splinter proofs. The velocity of the fragments on bursting may be estimated from 380 to 480 m. (1250 to 1575 feet); we may safely reckon, therefore, upon an unfavorably formed piece of 10 g. weight having a sufficient final velocity at 70 m. beyond the bursting point.

For the more recent type of shell, the limit for the distance beyond which the fragments become ineffective is set, not so much by the loss in final velocity as by the excessive scattering of the pieces.

It is not as easy with shell as with shrapnel to calculate the number of pieces falling on a square meter of a surface, because with the shell the sheaf is hollow and the dispersion is so great. Without any great error the distribution of the bullets from shrapnel upon a perpendicular cross section of the sheaf may be taken as uniform, for the distance of all the bullets from the point of bursting is about the same, on account of the small angle of opening. This is far from being the case with the sheaf of the exploding shell, on account of its large angle of opening; for the distance from the point of bursting of the outer bullets will then be much greater than the perpendicular distance of the cross-section plane from the bursting point and considerably greater than the distance of the inner bullets from the same point.

Since the dispersion of the fragments depends on the distance from the point of bursting, it is convenient to calculate the thickness of distribution of the pieces as though they were on the surface of a sphere. Taking the point of bursting as the center of a sphere, the sheaf will cut a zone out of the sphere, the area of whose surface at a distance r from the point of bursting will be equal to $2r^2\pi(\cos 45^\circ - \cos 55^\circ)$, taking 45° and 55° as the semi-angles of the exterior and the inner hollow cones. Supposing that 150 of the 500 fragments move nearer to the axis and may be neglected in dealing with concealed targets, then the thickness of distribution of the remaining pieces is expressed by:

$$\frac{350}{2r^2\pi(\cos 45^\circ - \cos 55^\circ)} = \frac{417}{r^2}.$$

The following table indicates the thickness of distribution:

Distance in meters from point of bursting.	Hits on 1 square meter of surface.	Distance in meters from point of bursting.	Hits on 1 square meter of surface.
2	104	22	0.9
4	26.1	24	0.7
6	11.6	26	0.6
8	6.5	28	0.5
10	4.2	30	0.5
12	2.9	32	0.4
14	2.1	34	0.35
16	1.6	36	0.3
18	1.3	38	0.3
20	1.0	40	0.3

It is easily seen that the shell will not have much effect except near the point of bursting, the more so as the targets are small and only a portion of the projectile at any rate can be expected to be effective.

To obtain a clear idea of the action of the shell, the spread of the fragments on the surface of the ground must be known for a given height of bursting. Since we take into account only such as burst near the target, the trajectory of the fragments may be considered as straight lines.

Denoting the angle of fall of the projectile at the point of bursting by α, the steepest angle of fall of any fragment by β, the horizontal distance of point of bursting in front of interior crest by S. the vertical height of point of bursting above crest by h, the expression for the spread of the fragments on the surface of the ground will be

$$2\sqrt{(\tan\beta - \tan\alpha)^2 \times S^2 - (h - S\tan\alpha)^2}.$$

This may be illustrated by an example. At 2100 m. the angle of fall α is approximately 7°, the steepest angle of fall, β, of any fragment in the cone equals 55° plus 7°, or 62°. The spread of the fragments is therefore

$$2\sqrt{(\tan 62^\circ - \tan 7^\circ)^2 \times S^2 - (h - S\tan 7^\circ)^2}$$

$$= 2\sqrt{(1.157)^2(S^2) - (h - S\tan 7^\circ)^2}.$$

The following table gives the spread of the fragments, the breadth of the space free from fragments, and the difference of the two (which will be the breadth of target that can be hit), for various horizontal and vertical distances of the point of bursting.

TABLE II.

Horizontal distance.	Spread of fragments on the ground.				Breadth of space free from fragments.				Breadth of target that can be hit.			
	for a height of											
m	3 m	6 m	9 m	12 m	3 m	6 m	9 m	12m.	3 m	6 m	9 m	12m
2	4.4	—	—	—	—	—	—	—	4.4	—	—	—
4	13.2	8.8	—	—	7.8	—	—	—	5.4	8.8	—	—
6	20.6	18.2	13.1	—	13.0	9.2	—	—	7.6	9.0	13.1	—
8	27.8	26.2	23.2	17.6	17.8	15.2	9.0	—	10.4	11.0	14.2	17.6
10	—	33.8	31.6	27.0	—	21.0	17.2	8.5	—	12.8	14.4	18.5
12	—	41.2	39.4	36.6	—	26.2	23.4	18.1	—	15.0	16.0	18.5
14	—	48.4	47.0	44.8	—	31.2	29.0	25.0	—	17.2	18.0	19.8
16	—	55.6	54.4	52.6	—	36.2	34.2	31.2	—	19.4	20.2	21.4
18	—	—	61.8	60.2	—	—	39.8	36.8	—	—	22.0	23.4
20	—	—	69.0	67.6	—	—	44.4	42.2	—	—	24.6	25.4
22	—	—	76.2	75.8	—	—	49.3	47.6	—	—	26.9	27.2
24	—	—	83.4	82.2	—	—	53.7	52.0	—	—	29.7	30.2
26	—	—	—	89.8	—	—	—	57.0	—	—	—	32.8
28	—	—	—	97.0	—	—	—	62.5	—	—	—	34.5
30	—	—	—	104.2	—	—	—	67.4	—	—	—	36.8

In the foregoing table, when the horizontal distance for point of burst becomes more than 2½ times greater than the height, no entry is made in the table, because in that case the steepest angle of fall of any fragment is less than 22°, and hence would have no effect on a concealed target.*

It is true that the dimensions assumed for the angles of the inner and outer cones (90° and 110°) are but approximations and can lay no claim to accuracy, nor is the inner space entirely free from hits, nevertheless it still holds true that even when the shell bursts comparatively close to the target, a considerable portion of the front of the target will be untouched. To obtain satisfactory results, therefore, the target must present a long front (60 meters, or more if the fire is distributed).

It also follows from the table that the depth over which a shell is effective depends in a large measure on the height of the point of bursting. For a height of 3 meters the mean effective depth is about 6 meters; for a height of 12 m., the mean effective depth is about 22 meters. If the angle of protection is increased, the effective depth is diminished in a very marked way; for an angle of protection of 45°, it is only 0.468 h. The horizontal distance for a height of bursting of 6 meters must be less than 6 (6 cot 45°), and greater than 3.2 (6 cot 62°), and the effective depth is only 2.8 m. For a height of bursting of 12 m., the horizontal distance must be between 6.4 m. and 12 m., and the effective depth is 5.6 m. It follows therefore that up to a range of about 2500 m., more effect is to be expected from a point of bursting somewhat higher than that laid down in the firing tables.

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* Entry also omitted when horizontal distance is less than one-half the vertical, in accordance with what has before been shown.—Trans.

Of course it must not be forgotten, in this connection, that by taking higher points of bursting, the distance from the target may be so increased, that the fragments will be too thinly strewn.

The next tables give an idea of the probable number of effective shots firing at targets protected against angles of fall of 22° and 37° respectively; the variation in the point of bursting is assumed to be laid down in firing tables. Shots whose distance from the normal point of bursting is more than 20 m. are not considered to be effective. Should the variation in point of bursting be greater than that laid down in the firing tables, and it always will be in battle, then for the more favorable points of bursting a slight deduction in the number of effective shots will have to be made, and for the less favorable positions, a slight increment must be made.

TABLE III.

Height of bursting. m	For a mean horizontal distance of + 40, + 30, etc., and a mean height of bursting of 2, 4, 6 meters etc., out of 100 shots at a target protected against 22°, the probable number of effective shots.										Total.
	+ 40	+ 30	+ 20	+ 10	±0	— 10	— 20	— 30	— 40	— 50	
2	2	5	9	11	9	6	3	—	—	—	45
4	1	5	11	15	17	16	6	3	—	—	73
6	1	4	8	17	22	27	13	9	3	—	104
8	1	3	7	12	18	28	18	13	7	2	109
10	1	2	5	10	14	25	18	14	9	4	102
12	—	1	3	6	10	20	15	14	10	5	84
14	—	—	—	2	6	16	12	9	9	4	58
16	—	—		—	2	5	6	6	6	4	29
18		—			—	—	1	2	3	2	8
Total.	6	20	43	73	97	143	92	70	47	21	612

It will be seen from the above numbers that for the 22° angle of fall a mean height of bursting of 8 meters, and for the 37° angle of fall, a mean height from 10 to 12 meters gives the greatest probable number of effective shots. (The mean height of bursting at 2000 m. is given as 5.4 m. in the firing tables).

It is laid down in the firing regulations that in engagement a single range will not be adhered to, but 3 ranges taken differing by 25 m.; of these one or perhaps two is effective. For example,

TABLE IV.

Height of bursting. m	For a mean horizontal distance of + 40, + 30, etc., and a mean height of bursting of 2, 4, 6 meters etc., out of 100 shots at a target protected against 37°, the probable number of efiective shots.										Total.
	+ 40	+ 30	+ 20	+ 10	± 0	— 10	— 20	— 30	— 40	— 50	
2	1	1	3	4	3	1	1	—	—	—	14
4	1	3	5	6	5	5	2	—	—	--	27
6	1	3	6	7	9	8	5	2	1	—	42
8	1	3	5	9	10	14	7	5	2	—	56
10	1	2	4	9	11	18	8	6	2	1	62
12	—	1	2	5	10	19	13	9	5	2	66
14	—	—	—	2	5	15	12	9	5	2	50
16	—	—	—	—	1	5	6	6	5	3	26
18	—	—	—	—	—	—	1	2	3	2	8
Total.	5	13	25	42	54	85	55	39	23	10	351

if 2000 meters is the desired range, then ranges of 2025, 2050 and 2075 meters will be used interchangeably, and with the fuze properly burning, and the center of impact at the target, the positions of the point of bursting will be given by the following co-ordinates measured in meters from the target (—25, 5 to 6), (±0, 5 to 6), (+25, 5 to 6).

Entering table 3 for 22° protection in cover, with these sets of co-ordinates, we obtain for the three a total of 39 effective shots out of 300 fired, or about 13%.

Using the same co-ordinates in table 4 for 37° protection, the effective shots amount to 16 in 300, or 5⅓%. This example takes the most favorable case.

If the center of impact was at —25 meters, we obtain, with the time fuze, as the positions of the mean bursting (—50, 5 to 6), (—25, 5 to 6) and (±0, 5 to 6).

In this case for the cover giving 22° protection there would be only 33 effective shots in 300 rounds, or 11% ; for the cover giving 37° protection there would be 12 out of 300, or 4% effective.

The number of effective shots would be still less were the target not forked, and it became necessary to take a longer space under fire by shooting at intervals of fifty meters.

In all cases, even under the most favorable conditions, only a very small number of effective shots are to be looked for, and hence a great expenditure of ammunition is to be reckoned upon. The effect of single shots is very different as the point of bursting varies in position.

If the point of bursting lies just above the line BZ (fig. 1) only the uppermost part of the target can be struck; the higher the point of bursting, the deeper can the target be struck, until finally the steepest fragment passes over the target.

TABLE V.

Height of bursting in meters.	Angle of fall in degrees of the steepest fragment that hits.	With a horizontal distance of 10 m. and height of bursting as in first column, the lowest point struck lies X cm. below the upper edge of a target 1 m. behind the cover, when the cover is		
		40	70	100
		cm. higher than the target.		
		x =	x =	x =
4	23¾	4	—	—
6	33½	26	—	—
8	41½	48	18	—
10	48	71	31	1
12	53	93	53	13
14	57⅓	115	85	35
16	60½	137	107	77
17	62	148	118	88

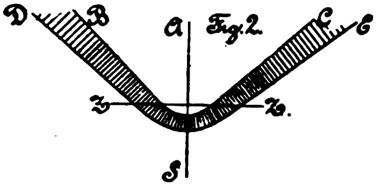
A comparatively high point of bursting has the double advantage that it increases the effective horizontal depth, as well as the vertical extent of target that may be struck. If the height of the point of bursting exceeds 17 meters for a horizontal distance to the front of 10 meters, then all the fragments will pass over the target,—even those at the steepest angle of inclination, 62°.

It is quite impossible, even approximately, to calculate the effect of a single shell, for the slightest displacement of the position of the point of bursting exercises an extraordinary influence on the result. It is not overstating the matter, therefore, to say that the effect of a single shell fired at a concealed target depends to a very large degree on chance.

Taking into view all the conditions that affect the action of shell, the chief fact regarding it is this, that appreciable effect can be expected only from those projectiles which burst at a point whose horizontal distance in front is less than 2½ times its height, and greater than one-half this height. If the shell bursts too far to the front, the effect is diminished because the fragments lose in final velocity and are too widely scattered. Hence an appreciable effect can only be expected from shell that burst close to the target, and even then a large portion of the front of the target will not be struck. A height of bursting from 8 to 12 m. corresponds to the greatest probable number of effective shots. According to table 3, horizontal distances from

—20 to +10 m. with heights of bursting from 8 to 12 m. give the best results.

While the bullets of shrapnel, falling on the ground, form approximately an ellipse with the bullets less thickly grouped at the center and on the edge, the fragments of a shell form a space limited by two parabolic lines, a result due to the inner hollow cone (see fig. 2). As the objective generally stands perpendicular to the axis of the parabolas, which coincides with the line of fire, it is evident that a large portion of the front of the target will not be hit. (SA is the line of fire, Z—Z the target, S the point of bursting, the shaded space between BC and DE receives the fragments). The fragments thus form a thin ring, widening as it recedes from the point of bursting.



From this it will be seen how little is the depth of the surface that can be hit; hence the firing must be very precise, and yet in spite of this, after many rounds, much of the surface exposed may be quite untouched.

The fact of the meager results to be obtained from shell with time fuze, shown mathematically by General Rohne, is confirmed by actual tests. Of course, in firing this projectile, there is the great disadvantage that the batteries thus firing shell are no longer directed at the easier targets that are attainable as well by shrapnel, but are used against such as are difficult to cannonade effectually.

Though the losses to infantry sitting in trenches under fire from shell with time fuze, may not be so great as to drive them out, it will at all events make their situation no pleasant one, and while it continues, will prevent them from engaging in the defense.

Even with the introduction of field howitzers and mortars, shell should still be retained with the field cannon for the same purpose as before, since, however, the Better is the enemy of the Good, field howitzers or mortars should be employed when the enemy located in trenches is to be destroyed before the infantry attack closes in, provided these cannon can solve this problem. This last "provided" must be spoken so long as firing under war conditions has not clearly demonstrated a marked superiority of these curved fire cannon over the field guns for attacking concealed targets.

[Translated by Second Lieutenant *George Blakely*, Second Artillery.]

(TO BE CONCLUDED.)

SHRAPNEL FIRE FROM FIELD HOWITZERS AND MORTARS.

Discussion by Martin Prehn, Captain in Department of Fireworks. Former Superintendant of Proving Ground of Friedrich Krupp, Meppen.

Archiv für die Artillerie und Ingenieur-Offiziere, February, 1896.

CONCLUDED.

But, great as this concise statement shows the results of the shrapnel from howitzers and mortars to be, they are not sufficient to warrant the introduction of a special gun of which the ammunition and its packing in the limbers and ammunition wagons, and of which the service differs throughout from that of the field gun, as against the use of a single gun for both purposes. This demand for a special gun is not warranted if, with a 1.0 kg. charge, the 12 cm. howitzer fires several shots at 1980 m., with normal bursting point, and fails to hit a single rifleman at the breastworks. The service of the piece, on account of uncertainty over the charge and the difficulty about clearly making the three corrections to follow, is often confused and the efficiency of the gun can be easily placed in question. Furthermore, in the firing above, the results were obtained by an observer who stood near the target, but, if the observer remained in the battery, the firing might become so unreliable as to wholly nullify the results. This is the view held by opponents of high angle firing in field warfare.

It then follows that the advocates of high angle firing must obtain a satisfactory solution for the following problems: 1. Simplification of the service of the pieces, and, 2nd, insuring the effect of shrapnel fire from howitzers and mortars, by increased action of the separate shots.

If it were a question merely of obtaining the greatest possible angle of fall, then, unquestionably, the smallest charge, suited to the distance, would be used. The proper charge is not only determined by the effect of single shots, but is also limited by the condition of facility in the service of the piece. The greatest possible charge must also be investigated. It has been shown, in the firing of the 12 cm. howitzer above, that the charge of 1.0 kg. was as effective as the charges of 0.5 kg. and 0.6 kg.

as far as the number of hits is concerned, and therefore the velocity of 225 meters of the 12 cm. shrapnel is in this respect fully equal to velocities of 161 meters and 140 meters. Although by chance with the larger charge at the range of 1980 meters no hits were obtained on the silhouettes standing at the breastworks, yet at 1500 meters the efficiency was as great as that from the charge of 0.5 kg.

In field warfare it would not be desirable to assemble more than three charges for the howitzer, and so arrange them that the sum of the two smaller equals the larger. For the 12 cm. howitzer these will be 1.0 kg. + 0.5 kg. = 1.5 kg., or 0.9 kg. + 0.6 kg. = 1.5 kg. Between 1.0 kg. and 0.9 kg, or between the velocities of 225 m. and 210 m. there is not an important difference.

For stability of flight, both on account of the oscillation of the axis and resistance to side winds, besides the energy of rotation a certain living force of translation is necessary to preserve stability. And since, with the 15 cm. mortar, the charges of 1.0 kg. and 0.75 kg. appear equally efficient in regard to the number of hits, and the probability of striking the target seems to be somewhat in favor of the large charge at least up to 2000 m., it will readily be seen that the living force of the projectile is appropriate. This living force equals that of the 1.0 kg. charge with the 12 cm. shrapnel, since $163^2 \times 31.4$ is very nearly equal to $225^2 \times 16.5$. It must therefore be concluded that 1.0 kg. is the proper minimum limit of the charge.

In order therefore, in the use of the newest powders, to combine simplicity of service, proper accuracy, and the greatest probable number of hits, a charge which will give an initial velocity of about 225 m. must be selected for the 12 cm. field howitzer. Should the shrapnel for this howitzer be made heavier (20 kg.) and lengthened, for which there is no occasion, because the one containing 285 balls of 26 gm. weight has not shown itself inferior in the number of hits to that containing 460 balls of 16 gm. weight, the minimum velocity for the necessary living force of the present shrapnel would have to be taken at 205 m. An increase in the length of the projectile, with this velocity, would increase the oscillation of the axis; so that in this case too we would want at least 225 m.

Since in firing the 12 cm. howitzer at 1500 m., the charge of 1.0 kg. with the slight elevation of 8.8°, gives the same result as 0.5 kg. with 22.5°, it becomes a vital question whether a minimum limit of elevation or a minimum velocity should decide the question of the choice of a charge. In the same way, in firing at 1975 m. with the 15 cm. mortar, the service charge of 1.5 kg., 210 m. initial velocity, with elevation of 12.4°, would appear superior to the smaller one of 1.0 kg., 163 m. with 22.8° elevation, but this is not the case.

In an experiment similar to the last, a comparison was made of the 1.0 kg. and 1.5 kg. charges. With the first charge, a bursting point —100 m. and 18 m. high, in 5 guns, 8 men were hit, but the whole battery received only 22 balls; with —65 m. and 8 m., 4 men were struck, the battery received 25 balls; with —65 m. and 8 m., 6 men (10 hits), in all 32 balls; as against, with the 1.5 kg. charge, with —30 m. and 1 m., only 6 balls in the battery; with both —15 and 12 m. and —25 and 10 m., only 3 balls in the battery. The following principle may be deduced: the living force with the 1.0 kg. is sufficient for stability of flight, yet on the other hand so small that the bursting charge checks it in a way to increase the angle of fall of the balls, while the bursting charge does not affect the velocity from the 1.5 kg. charge in the same favorable way, and the balls, on account of their high velocity, but little changed by the burst, pass ineffectively over the target.

The 12 cm. howitzer was fired with shrapnel at 3600 m., at a similarly constructed target using both the 1.5 kg. and 1.0 kg. charges, both of which failed to satisfy the expectations. The smaller required 28.3° elevation, the larger only 16°. The service charge of 1.5 kg. gave in one case, with bursting point of —35 meters and 12 m., 14 hits in 9 men, in all, 47 balls against —35 meters and 15 meters high, only 6 balls in the battery, and the results remained unsatisfactory during the firing. In the first case the axis oscillation downwards had evidently benefitted the result. The charge of 1.0 kg. gave no greater number of hits but was considered equally good. It was concluded from this that for distances between 2000 and 3600 meters, the medium charge of 1.0 kg. deserved the preference on account of simplicity, but at 3600 meters the stability of flight is not good with this charge, and the remaining living force not sufficient for lateral resistance.

In pitched battles it will be beyond the province of field guns to fire at distances of more than half a German mile at such small targets since they cannot inflict substantial damage at that range under those conditions.

It is naturally otherwise in sieges, since in this case the approaches to the position will be held under shrapnel fire from field howitzers and mortars with medium and heaviest charges. But of still greater value will be the shrapnel fire from howitzers in sieges, in cases where this gun, on account of its mobility even when moved by hand, will be called on to reach every part of the enemies' work. The light howitzers will be so much the more fitted for this work (indeed, they will be almost indispensable) since they, among all the guns of large caliber, use a nearly or quite smokeless powder.

In this way will the maximum charge be used. In a similar manner will the field howitzers be used to keep up a slow disturbing fire with full charges over large closed field works and intrenched camps. In this manner with different pointing and different distances will the efficiency of shrapnel be brought out.

If the comparison shows that the field howitzers and mortars are in every way superior to the field guns in indirect fire, and that the latter do not give results which correspond to the highest expectations at the ordinary fighting ranges, the high angle guns, although not wholly favorable, must be acknowledged as necessary. The accuracy of these guns must become unquestionable, and for that purpose it will be almost obligatory to reduce its service to the simplest possible form by establishing a single charge for indirect shrapnel fire, or a single velocity, for which 225 m., for the 12 cm. field howitzer with 16.5 kg. weight of projectile, recommends itself; and the greatest proficiency in the service of the piece should be reached by extended exercises in firing, and observation by specially trained artillery men.

If only one charge is used this training will soon be gained. Differing from those cannon and small arms using powder producing but little smoke, in which the flash of explosion and the throwing up of sand by the projectile can be seen usually with difficulty, the clouds of smoke produced by the burst of this large shrapnel are very easy to see either when bursting in the air or on the ground at point of fall. It is naturally fitting, that the range be obtained by the commander of a gun battery, since the ammunition of the howitzer on account of its weight and small number is too expensive.

In every case the firing must be conducted so as to strike the parapet with percussion fuze—then the time fuze will be set at that division which corresponds to the time of flight taken from the range table, in order to control this part of the fuze. Then a difference in elevation of 0.4° and the same length of fuze before taken used, unless that has shown itself as too short. If the bursting point is too low, but this side of the parapet, which can easily be seen, then 0.4 seconds should be taken from the time fuze; if the bursting point is behind the breastworks. 0.6 seconds is taken from the time fuze, but this difference in time should correspond to a difference of 75 m. in the range, as shown by the range table. From this on a slow fire is kept up without correction, unless obvious errors are shown.

The deflection allowance demands careful attention. With no wind, as many points ($\frac{1}{1000}$ range or $\frac{1}{16}$ degrees) left are taken as the elevation shows whole degrees. For a left wind, one fourth to one third of the number of points already taken are added, and for a right wind the normal deflection allowance is decreased by a similar amount—a rear wind has but little influence on the flight of the projectile, unless it be a storm; a front wind requires somewhat greater elevation, which is determined by firing. Side winds may be sufficient to double the deflection allowance or to decrease it to nothing. The rest is the same as with cannon.

It has been found by experiment with fuzes, that in howitzers and mortars they burn very regularly in proportion to the time of flight or possibly a little slowly, or the reverse that has been observed with the high velocities of cannon. With the cannon, as we well know, the fuze burns very quickly at the beginning and decreases in velocity of combustion in a ratio directly proportional to the decreasing velocity of the projectile.

Therefore the great value of as undisturbed and quiet service as can be obtained will be very readily seen. Wild firing must always be guarded against, and the actual efficiency must be counted on fully as much as the moral affect of the loud noise of the explosion.

On account of the low velocity and the circumstances connected therewith, it is recommended in practice on account of the large volume of smoke of the burst, and the long time of flight of the high angle shrapnel as compared with that of cannon projectiles, that the time of flight be measured by a watch or some instrument specially constructed to measure seconds. By firing with percussion fuze, the firing will be freed from all influence of the weather on account of the necessary connection between the time of flight and the setting of the howitzer fuze, and the battery will be oriented with regard to the burst. Good service can often be rendered to neighboring cannon in battle through such observation, if the range is taken out of the range table corresponding to the measured time, and in this way furnish the data for them to get the distance to the target.

The second point for consideration in endeavoring to increase the efficiency of shrapnel of field howitzers and mortars in firing against covered troops is the question of increase in bursting charge and by thus increasing the cone angle of the sheaf, the bursting point can approach nearer the crest of the parapet. The torpedo shell would serve as a model for this. In regard to the efficiency of this shell, which for the present is kept with great secrecy, very little has been openly published. What is sufficient for the foregoing purpose has already been published in books, and that is its undoubted increase in cone angle of dispersion. The cone angle of the shrapnel for 12 cm. howitzer is from 16° to 20°, which is sufficient for firing with the largest charges at troops standing in the open, but if they are covered, in such a limited sheaf, too many of the balls pass over the target.

Considering, then, a torpedo shell with a cone angle of 110°, in the interior of which is a vacant space of 90°, so that only a small ring of 10° can be effective; it is not easy to see how a covered firing line can be reached with this if it is not supplied with a fuze of unheard of accuracy, and an accuracy of observation which can hardly be obtained. Most of the bursting points which can be observed naturally lie in front of the target, and the fragments will be lost in front of the target in this case, in a manner similar to that in which the shrapnel balls of a shrapnel whose bursting point is behind the target, are lost on the other side. The upper half of the sheaf is always lost to the target.

The loss of shrapnel balls behind the target will in reality be only apparent since only a single line can be covered to a high angle but never a larger body of troops, especially if they are dispersed. The conditions will be still more unfavorable if, as has already been stated, every man believes himself covered, because he simply cannot see the enemy's guns; the safe angle of covering will certainly not be measured by any one. This will generally be the case in artillery positions in the field where the bringing up of ammunition and the recoil of the guns always cause movements behind the covering. Although it is calculated that with a comparatively small number of shots, from 30 to 36, all the cannoneers of an open battery may be destroyed, it must also be remembered that the artilley rof the enemy is itself firing with a view to our destruction, and has the same chance of destroying us; it has been learned on the target range, that a single shot may strike down all the cannoneers of a single gun together with the horses, and therefore our guns will lose their cannoneers in a similar manner to the enemy's, or they may become very much excited, so that the conditions will be entirely different from those on the target range. Besides, the torpedo shell demands much more quiet and accurate placing than the shrapnel.

Without lifting the official veil, it is concluded that a great deal is expected from the fragments of the shell, which, through the checking force of the bursting charge, will work backward in a direction contrary to the trajectory. Indeed, in the French shell, this kind of recoil efficiency is largely counted on, and also in the *obus à mitraille*.

It appears, therefore, that, if anywhere, torpedo shells will find their true place in the fire of high angle field guns. The checking force of the bursting charge would entirely overcome the small velocity of 225 m. of the 12 cm. howitzer. So loaded the weight of the shell can easily be raised to 20 kg. without thereby essentially raising the limit of weight of limber load. On account of its powerful effect, this gun has not as great necessity for speed as the cannon.

It will appear that the shrapnel is still more fitted for the high explosive without exceeding the weight of 16.5 kg. The charge could not be as large as in the shell and would therefore make the angles of dispersion somewhat smaller. The more important consequence would be that the sheaf would be less hollow than in the shell since through the pressure of the gases the force of projection will lessen the radial spread of the balls, and the useless broadening of the sheaf will therefore be lessened. In such a shrapnel, in which the forward movement is not only fully destroyed but the torn and rent base has a great backward velocity there will be a necessity of placing a limit on the forward velocity of the balls. That is very easily accomplished if a part of the balls is removed behind the fuze, say two layers, and the space so gained filled with high explosive.

In this way the balls are brought between two fires, which burst the case, and produce a very great number of large destructive fragments which fly close enough together to destroy a target. By storing the strong explosive behind the fuze the delay of the full ignition will be removed without being obliged to resort to a new construction.

This projectile would show the same superiority which is attributed to explosive shells, but its efficiency would be the greatest with low velocities out of large calibers. It is of course understood that a combination time and percussion fuze would be used, it thus becomes much easier to regulate the firing since no loss is feared even if the target is fired over—and the fuze can always be cut to correspond to the actual time of flight.

At the beginning of such experiments it would seem advisable to use the high explosives at different strengths and not to commence with the strongest. It may be recommended to find a charge of ordinary nitro-glycerine of the smallest proportions for the bursting chamber, which will be ignited by a large charge of potassium nitrate powder lying behind the fuze, to break the base of the shrapnel. Moreover, to place the charge behind the fuze of cubic powder (Würfelpulver), might perhaps fail of efficiency on account of the slow ignition, but would considerably increase the effect. Perhaps the slight delay would be favorable to the action of percussion fuze to get a burst above the ground. These experiments must then be followed by others with stronger explosives in the chamber, avoiding the well known powerful percussion fuze always used now with the above charges of potassium-nitrate powders. The rest follows of itself.

Would the entire supply in the limber consist of high explosive shrapnel? Before more experience is had, not over one half; since those charged with black powder are to be preferred against troops in the open, with the heavier charge of 1.5 kg. in order to have greater depth of sheaf against narrow objective. A battery of six or even four howitzers will not fire all their high explosive shrapnel against a single target.

The objection may still be made to the 12 cm. howitzer on account of its clumsiness and its inability to protect itself, because of the weight of its ammunition, the number of projectiles naturally can be less only in case these weighed only one-half as much. It is also a little inconvenient not to be able to borrow from a neighboring limber since a single howitzer battery will often stand alone. But in all other respects it is as independent as a cannon battery. The mobility of the howitzer is the same, its service does not require any more men, it is furnished with a large projectile for bombarding at 6000 m., and in close combat its efficiency in the open is fully as great if not greater than the cannon battery, and when necessary the howitzer can also deliver a rapid fire.

APPENDIX.

In accordance with the wish of the editorial management, that a few remarks be added to the foregoing paper from the standpoint of field artillery, the undersigned does so the more readily since the subject is at present one of the utmost importance, and considered by all armies as in the foreground of interest; and thereby opportunity will be taken to express a view differing from it in many points and perhaps in that way assist in clearing up this important question.

For the last ten or twelve years, ever since the more advanced methods of directing troops have demanded that the assaulting body of infantry, while waiting inactively behind cover, must be fired upon by artillery, this question has occupied the attention of thoughtful artillery officers. When it had become very clear that this object could not be attained by the ordinary means at the disposal of artillery, the most varied methods for its solution have been proposed. At the beginning, as is quite commonly the case even to-day, the difficulties of the task were very much underestimated, and, on that account, numberless experiments were tried with insufficient means, among which are to be counted the endless trials to solve the problem by means of shrapnel fired with reduced charges from field guns. I expressed my opinion very early, that the solution of the problem would not be reached by this means (vol. 94, 1887. "What basis is there for the introduction of small charges in field artillery?").

At that time in harmony with Major Leydecker, whose views on the expediency of small charges I opposed, the adoption of a field high angle gun for shrapnel was proposed, based upon reasons entirely coincident with those given in the above discussion.

Very soon afterward the means were discovered of firing without danger projectiles charged with high explosives from cannon, and as early as the spring of 1888 I showed that this projectile possibly offered a solution of the question. ("Another discussion of small charges for field artillery." Vol. 95, 1888). The question at that time was: shall the field artillery adopt a special gun, or a special projectile, for reaching troops close behind cover: shall the field howitzer or torpedo shell be adopted; it being understood of course the field howitzer with shrapnel, since the idea of making the field howitzer sufficiently strong to withstand the bursting of a torpedo shell in the bore (and this demand was made), seemed to be excluded from the beginning. The decision was made in favor of the lesser evil, the torpedo shell, since there was no necessity of reducing the charge.

This hasty decision did not conclusively settle the question; between the advocates of the torpedo shell on the one side, and those of the field howitzer on the other, there was no peace, only a suspension of hostilities. There were fanatic admirers of the torpedo shell, who in their infatuation had accepted it as the best and only projectile for field artillery (see *Militär-Wochenblatt*, No. 1, 1893; "Simplification of ammunition supply for field guns," which paper treats of this error), and there were adherents of the field howitzer who attributed to this gun not only the ability to fight against covered troops but also to take part with success in the artillery duel. (See *Militär-Wochenblatt* No. 110, 1891: "The field gun of the future, and the field gun for coming requirements"). The author of the present paper belonged to the last class.

My belief is that one must guard against setting too high expectations on the field howitzer; there is one objection which it is almost if not quite impossible to overcome. It ought to be effective in the first place against covered troops, and this supposes a highly curved trajectory with wide angles of opening of the sheaf. It ought at the same time to give good efficiency against troops standing in the open, but these can only be reached by a flat trajectory and narrow sheaf. The author of the above mentioned article has also very accurately noted this fact, and in order to overcome the difficulty he would provide the gun with two kinds of ammunition; namely a shrapnel against open targets with greatest possible charge ($V_0 = 290$ m.) and narrow opening of the sheaf (base charged shrapnel), and a second shrapnel against covered targets with smaller charge ($V_0 = 140$ m. to 225 m.) and wide opening of the sheaf (shrapnel with base and point chambers, both filled with high explosive). Doubtless this is the only way of satisfactorily overcoming the difficulty.

But the question here arises, whether, uniformity having been once abandoned, it would not be expedient to employ the present field guns with decreased charges and a projectile of somewhat wider opening of the sheaf, but not so wide as that of the torpedo shell c/88.

The author of the foregoing discussion, who has had a very great experience, since there is perhaps no officer in the German Empire who has conducted so many experiments, considers this solution impossible because the large chambers of the long cannon cause the small charges to fly apart, thus preventing uniform combustion from shot to shot (p. 165).

Doubtless this proposition is supported by an exceptionally extensive observation, but, nevertheless it is my opinion that this is not necessarily the case. Since the shots to be fired with reduced charges are packed in special wagons, there is no reason why with them there should not also be a specially quick burning powder to equalize the velocities from these large chambers. Should this not be successful what hinders us from making these large chambers smaller? The means for doing this are not lacking, such as lengthening the projectile, or if that fails, as is easily conceivable, to meet the requirements by the insertion of a pasteboard or similar cylinder between the projectile and the charge as has been done by the French in their short 120 mm. cannon. I think that without doubt success would be achieved by this means; not that I believe the efficiency of the cannon so fired would be equal to that of the howitzer against covered targets, but in the sense that its efficiency would be naturally increased over what is now attained or attainable by present methods.

As no one can serve two masters, so every gun, which serves two so widely different purposes, will be indifferently fitted for both, or efficient only for one. In this way the field gun which is very efficient against open targets has only a moderate effect on covered targets and conversely the field howitzer which has a good efficiency against covered targets, in its work against open targets, will lack much of accomplishing the required result. But too high expectation must not be placed on the efficiency of the field howitzer against covered targets or otherwise many disagreeable disappointments may be experienced.

What has been said of its efficiency with shrapnel against such targets can now give no basis upon which may be judged its actual work. These results do not equal by a great deal those which are obtained under similar circumstances by the field gun with torpedo shells; it being understood that the basis of comparison is not the number of hits per projectile, but per unit of weight of projectile, a means of comparison to which there can be no objection.

In reference to the numbers given in the tables above it must not be overlooked that:

1. The targets were often covered only against very small angles of fall, and those that were covered against an angle of fall of 22° showed very few hits. The targets, erected for field artillery on the target range, and fired at with torpedo shells, are covered under angles of fall of from 22° to 36°.

2. The corrections were based upon observations made at the targets, and under such circumstances torpedo shell from field guns are much more efficient than shrapnel from howitzers.

Whenever observation is easy, the firing is successful, and the results accomplished under these circumstances by the torpedo shell of the field gun are so entirely satisfactory, there is no necessity of striving for greater efficiency. As long as the old works constructed on the target range for the use of the foot artillery were utilized for the erection of the targets, the work of the torpedo shell was so far preferable that at once many officers were so taken by it that they desired it as the only projectile.

Since that time this high covering has disappeared and the targets have become of field pattern, and the expected efficiency is lacking, and indeed for that very reason, since the observation became so difficult that the firing very often failed.

The probability that the difficulty of observation was due to the target rather than the projectile is a thousand to one, and the same result would be obtained in using high angle guns. It is not because the torpedo shell demands an accurate firing but because the target is so small and so well covered. The introduction of a high angle gun would not change these conditions in the least. An efficient result can be expected with the howitzer only by using a projectile with very wide opening of sheaf, at all events I am of opinion that the construction of the projectile has at least equal importance with the curve of the trajectory. Where both these factors combine with surrounding circumstances it can be readily understood that there is a more favorable prospect for a satisfactory result.

There is no difference of opinion that if the field howitzer is to be introduced in general use, it should be represented only in small numbers.

The only justification for their introduction would be that their efficiency is so superior to that of cannon that they cannot be replaced by several of the latter firing at the same target.

My opinion of this weighty question may be briefly stated as follows:

1. The more advanced methods of directing troops, if properly followed, demand that men close behind covering, who do not themselves take part in the fighting, should be effectively reached by field artillery and therefore there must be sought an effective means to reach them by firing torpedo shells from field guns with service charges.

2. A high angle gun that fires only shrapnel with narrow opening of sheaf (about 30°) is no such means.

3. As a means for attaining this result are offered

a. A torpedo shell or shrapnel out of field guns with reduced charges, if they have a cone angle of from 80° to 90° and the cone angle is less hollow than in the present torpedo shell.

b. A field howitzer with projectiles which have a wide opening of cone angle of from 60° to 70°, like those proposed in the foregoing article.

c. If neither of these two means bring about a substantial increase of efficiency, there remains the method adopted by the French, their walled torpedo shells with very large charges, perhaps the last resort. Dependence is placed in this case, not on the work of the fragments but on the atmospheric pressure due to detonation of the projectile. It is a desperate means and it can therefore be easily understood that no other country has adopted it. (See *Revue d'Artillerie*, February, 1896).

All these ways should be simultaneously introduced, according to my opinion, so that without loss of time, the means accomplishing the greatest result could be ascertained.

Now only a few details, which only slightly touch upon the main question but which are of sufficient importance to be elucidated, so that false conclusions will not be drawn from the above discussion.

In my opinion the bursting of the shrapnel is not properly described in the foregoing. On page 167 it is stated that the gas produced by the burning of the bursting charge exerts a pressure on the base of the projectile which results in a retardation of motion of the whole projectile.

This is entirely impossible and is caused by an easily comprehended optical illusion. The gases not only exert a pressure on the base of the projectile but also on the diaphragm and through this on the contained balls. By means of this pressure the body of the shrapnel, in case this remains whole, receives a velocity to the rear, while the balls have received a similar one to the front. The velocity imparted depends on the work performed by the bursting charge and the weight of the mass moved. The relations are similar to those which exist when a gun is fired, the projectile goes in one direction and the gun in the opposite direction.

Representing the weight of the body by B, that of the balls, diaphragm and point together by F, and by V_B and V_F their respective velocities, then the products of the two masses and their velocities must be equal, or, $BV_B = FV_F$.

If the projectile has at the bursting point the velocity V, after the burst the body will have the velocity $V - V_B$, and the balls $V + V_F$.

Now if the weight of the body is small in comparison to that of the balls, etc., as is the case in properly constructed shrapnel, the value of V_B may become quite large in proportion to V, which is always small in high angle firing. Therefore the reduction of the remaining velocity in the body of the shrapnel caused by the bursting charge may be very great, in fact it may entirely overcome that velocity and the body of the shrapnel receive a motion to the rear. In this way may be explained all the observed phenomena cited in this treatise; only the body of the shrapnel was confused with the whole shrapnel by the observer. The parts which fly forward do not form a single mass, and therefore are not seen by the observer; but they always receive an increase in velocity whenever the bursting charge is placed in rear of the balls. That a force in the projectile can destroy the work stored up in it by means of the charge in the gun, or can change it in ever so slight a degree, is contrary to all laws of mechanics. Moreover, the fact that a shrapnel held firmly in position by an abutment will, if exploded, give greater velocity to the balls through the bursting charge, than one exploded when hanging free, is also in full accord with what has already been said; to the weight of the body of the projectile is added the weight of the abutment which may be assumed infinitely great, and the bursting charge, which in the case of the suspended shrapnel performs work on both the body and the balls, in this case performs no work on the body of the shell. The total work of the bursting charge being approximately the same in both cases, the balls will therefore receive a greater velocity.

On page 339 there is a view expressed which ought not to go uncontradicted, especially since it is very widely disseminated. It is that the firing at covered targets by torpedo shells out of straight trajectory guns requires fuzes of unheard of accuracy. This is a view which has grown up only on target ranges which are not fixed according to war conditions, but fitted up for the particular object in view, and where observations are made at the targets. Now, where the position of the *mean* bursting point can be regulated entirely at will, a small scattering of the balls is naturally very desirable.

But the case is entirely different in actual battle, where the observations are unreliable, and where, even if observation were reliable, no fine corrections could be made. In this case the smallest error in the location of the mean bursting point would entirely ruin the firing, if the scattering of the balls was very small; whereas, by the scattering of the balls some effective shots would be obtained even though the position of mean bursting point was not absolutely favorable. The great accuracy of the gun does not always guarantee the greatest probability of hitting. So that one can almost say the scattering of the fuze is much too small, since it is well known that the firing rules require that the firing shall be conducted at three ranges differing by 50 m. Of course in this way the scattering in depth only is affected, in width it would remain the same.

Notwithstanding the fact that my views differ from those of the author of the above discussion in many points, I am of the opinion that in publishing it, he has done a valuable service toward the development of this important question. I believe that the proposition to provide shrapnel with chambers both in the base and point, is especially worthy of attention.

ROHNE,

Major General, Commander of the 8th Field Artillery Brigade.

[Translated by First Lieutenant E. S. BENTON, 1st Artillery].

Fig 1
Longitudinal Section

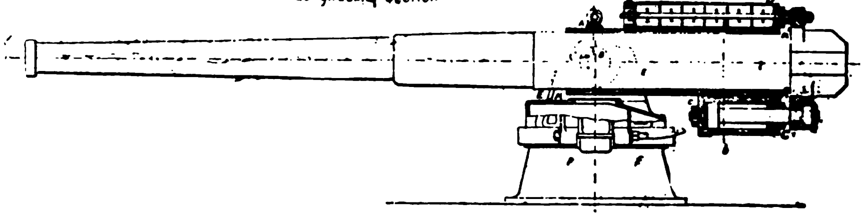
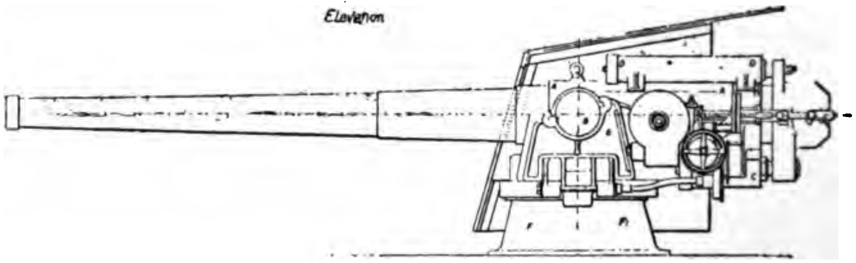


Fig. 2
Elevation



Plan.

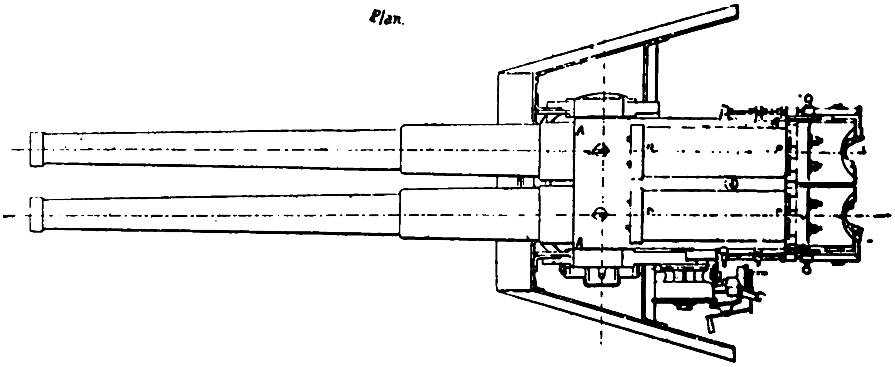


Fig. 3—SCHNEIDER-CANET DOUBLE-FIRE MOUNTING

PROFESSIONAL NOTES.

ARTILLERY MATERIAL.

a. Guns and Carriages.

Double Fire Schneider-Canet Mounting For Quick Fire.

The double fire Schneider-Canet mounting solves the problem of combining in the hands of a single gunner the chief organs of two quick-firing guns; that is the firing and pointing, including elevating and training. It allows the two pieces to be fired simultaneously in succession, and to be directed on the same point, and thus it obtains great results. With these special characteristics it combines great simplicity in working with a minimum weight and bulk.

The mounting comprises the following parts:—(1) The cradle; (2) the saddle; (3) the pedestal. The cradle consists of a double sleeve made of a single piece of steel, in which the guns recoil independently of each other (see A A, in Figures). This double sleeve carries in the front position, the trunnions B, and in the lower part the two brake cylinders C C of the guns. Above are placed the recuperator springs D D D D, independent of the brakes, securing the return into the firing position at all angles of elevation. On the left side is fixed the slotted arc for elevation.

The guns are furnished at the posterior end with the rings by which they are attached to the pistons of the brakes and the recuperators. The saddle E E consists of two checks, which take the trunnions of the sleeves, and it is carried downwards in the form of a central conical pivot which fits into a pedestal in a vertical socket. A cast arm on the left cheek supports the pointing arrangements—see Figures. The pedestal T T, also of conical form, is fixed on the deck, and supports the whole of the fittings for training and elevating—see Figure. The brakes C C are of the Schneider-Canet system, and constructed to give uniform pressure, and consequently to give the minimum of strain on the various parts. The recuperators are formed each of two cylinders of springs, and are independent of the brakes. The elevation of the sleeve carrying the two guns is put in action by a spring placed near the hand of the gun captain by means of bevelled wheels and endless screw gear—see Figure. Special arrangements to reduce friction to a minimum assure the complete and easy command of the mechanism by a single man. The gear for horizontal movement or training works in the same conditions as to rapidity and ease, the captain presses a spring which acts by bevelled wheels on an endless screw which moves on a toothed circle fixed on the upper part of the pedestal. The gun captain has equally under his control the handles for firing the two guns.

To sum up, the chief advantages offered by the Schneider-Canet mounting for double-fire, delivered with special speed, are the following:—(1) The combination of two guns on the same sleeve mounting, which permits the reduction of the distance between their axes to a minimum, and consequently to decrease in great proportion the couple acting laterally on the fittings when a single piece is fired. (2) Minimum weight. (3) Reduced encumbrance on the deck. (4) Complete solidarity of the two pieces, of which the direction and firing depend on a single man, having to his hand all the gear for working, and who can consequently follow the change in position of a moving object. (5) Rapidity of fire. (6) Great ease of working due to reduction of friction. (7) Minimum strain of parts. (8) Reduction in the number of the detachment needed to work the two pieces. (9) Facility of concentrating the fire of both guns on the same spot, and of thus obtaining great effect. The advantages, it is urged, allow a result to be obtained which is at least double that of those which are got by pieces detached, and at a greater or less interval. This type of carriage is said to be applicable to pieces of all calibers.

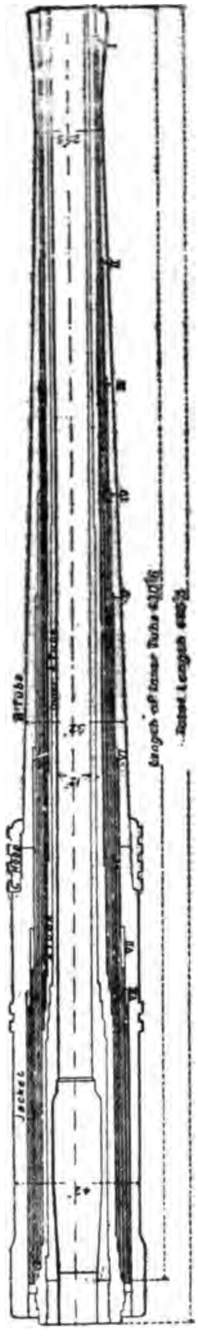
—*The Engineer*, March 4, 1898.

The Construction of Modern Wirewound Ordnance.

No. III.

We are glad to be able to put before our readers a longitudinal section of the latest existing 12 in. wire guns, Mark VIII., as they are known officially. A new gun of increased power is, we understand, under discussion. It probably will not greatly vary from that shown in the figure, except in increased length and strength in certain parts. The enormous length of the chase hoop to which we called attention in a previous part can now be appreciated. It will be noticed, too, that the wired portion extends right up to the muzzle, and perhaps it may be as well roughly to indicate some of the reasons which caused the War-office to adopt this pattern. To the difficulties of securing steel of equal quality throughout such a large forging as that required for the chase hoop, and the subsequent difficulties of manufacture, we have already alluded. Cogent reasons for deciding to entertain the risk and the increased cost were therefore necessary. The main argument in favor of wiring to the muzzle is that nearly all guns which have failed have done so in front of the trunnions or rings, probably because it is in this region that premature explosion of shells occur. The first of such explosions may not destroy the gun, but it will burst under subsequent accidents. By wire winding, both the chances of explosion and the damage resulting from explosion are lessened. Another reason is founded on certain experiments made at Woolwich some years ago to ascertain the effect of firing at the chase hoops of a 10 in. gun. It will probably astonish some readers to know that the bullet from a 1 in. Nordenfeldt caused the steel to crack in various direction almost like glass. The reason of this remarkable weakness is ascribable to a variety of causes. The thinness of the metal and the probable increased severity of the initial stresses, as well as the after effects produced by frequent firing, tend to harden it. In moderate-sized and small guns, for obvious reasons, it is unnecessary to take precautions against such an occurance. In the first place, the target presented is very small, and the radius of curvature is very sharp, so that a shot is seldom likely to strike dead true. In the 12 in. guns the smallest diameter is 21½ in., an appreciably large target for small quick-fire guns, and it is therefore necessary to take all possible precautions to reduce their suffering on being struck. Now the chase hoop in a wire gun has very little to do with the transverse stresses. These are nearly all taken up by the wire, and, consequently, the chase hoop does not have to be contracted so tightly on to the gun as when the solid method of construction is followed, and it is therefore less likely to fracture when struck. Moreover, supposing it was actually pierced by a small shot and the wire cut, the strength of the gun would not be appreciably lessened by so small a hole.

Returning for a moment to the subject of forgings, some additional examples of hydraulic presses are given. These are very representative types,



made by Messrs. Fielding and Platt. The special feature of presses constructed by this firm is the very simple and effective system of valves, the invention of Mr. John Fielding, whereby power is economised to the fullest possible extent, whilst the working is much simplified. This systemis applicable equally to presses worked by direct pumping, accumulator, or steam intensifier. The arrangement is such that pressure-water cannot be admitted to the press cylinder except for the actual pressing operation, even by the carelessness or want of skill of the attendant. There is, therefore, no necessity for limiting the length of stroke, so that ample clearance may be given to allow of free manipulation of the forging. The effort required on the part of the attendant is very slight, as only one small valve has to be handworked, all other valves belonging to the press and pumping engines or accumulator are automatic in their action.

The engines are very massively proportioned, and are automatically controlled by the action of the press valves. When the press is at rest the engines are kept slowly moving, so as to keep the cylinder warm and free from condensed water.

Presses worked by direct pumping are proportioned for a maximum pressure of three tons per square inch, steel cylinders lined with gun-metal and packed by cup leathers being used. For working the lifting cylinders a pressure of 1500 is employed. All packings, where possible, are of hemp, which Messrs. Fielding and Platt find by experience to be preferable, on account of the ease of removal. They regularly use this kind of packing up to pressures of two tons per square inch, with excellent results.

Steel is, of course, mainly used in the construction of these presses, cast iron being only used where its compressive strength makes it suitable, as in anvil block, distance pieces, etc. In addition to these heavier presses, Messrs. Fielding and Platt make quick-speed presses of smaller powers for general smiths use, stamping, etc., which hardly, however, belong to that part of the subject of hydraulic forging to which the present article refers.

A pair of horizontal direct-acting steam pumping engines, made by the Southgate Engineering Company, Limited, which have been specially designed and constructed for a foreign Government for working a 3000-ton hydraulic forging press for ordnance work, are what called the main pumping engines, and pump direct into the hydraulic cylinder of forging press. In addition to these there are the supplementary pumping engines, which pump through an accumulator at a pressure of 1500 lb. per square inch, and are used for lifting the ram of the forging press. The main pumping engines work at a hydraulic pressure of 3¼ tons per square inch. There are two steam cylinders, 32 in. diameter and 36 in. stroke, driving four pumps of 4 in. diameter, connected direct to the piston-rods of the steam engines. The bed plates of the steam engines are bolted to the end of the bed plates of the hydraulic pumps. The casing or chambers are of forged mild steel, made by Messrs. Firth and Sons, Sheffield, and the cylinders and valve boxes are drilled and finished from the solid steel forgings. The pipes connecting to the hydraulic forging press are connected directly to the ram of the forging press. They are controlled by a hydraulic valve, which is worked inside the forging shop. The steam cylinders are worked at a pressure of 150 lb. per square inch.

The following list of the average weights of the forgings - all forged hollow —of the principal parts marked upon the drawing of the 12 in. gun are of interest:—

Inner A tube or liner	7.9	tons.
A tube	13.6	"
Jacket	16.5	"
C hoop or connecting ring	2.5	"
B tube, muzzle jacket, or chase hoop	13.8	"
Breech fittings complete	1.1	"
The total weight of forgings, all forged hollow	55½	"
The total weight of wire	12	"
Total of rough material in gun	67½	"
The finished weight of gun is	46	"
Difference between weight of material rough, and polished gun	21½	"

As no appreciable amount is removed from the wire, this figure means that 21½ tons, or nearly half its weight of material—46½ per cent.—has to be removed from the forgings, and is lost in the construction of a 12 in. gun.

After forging, the hoop or barrel is "first" annealed; that is to say, it is raised to an indefinite high temperature, and allowed to cool slowly. The object of this operation is, of course, to remove the stresses set up in the material by forging. After this a long forging usually needs straightening, an operation usually performed under the hydraulic press; it is then rough machined all over, both inside and out, and rings and discs are cut off the ends, cut and turned down to suitable dimensions, and tested for elongation and breaking. This is technically known as the "soft" test. On the next two operations the working strength, as we may call it, of the steel depends. The forging is first heated to a temperature between 1450 deg. Fah. and 1600 deg. Fah., depending upon the opinion of the steel expert as decided from the first test, and from the furnace is lowered directly into a well of rape oil, where it remains till cool, the time required varying between six and twelve hours, depending on the size of the piece. As one large oil tank is generally deemed sufficient in a factory, arrangements are made, as far as possible, to work "shifts about;" that is to say, the day gang of workmen put a casting into the oil, which will be cool by the evening, and the tank ready for the night gang, their forging in turn being cool by morning. The tank is surrounded by a water jacket. It is, we believe, invariably sunk into the ground to a depth of between 40 ft. and 50 ft., and measures between 6 ft. and 7 ft. internal diameter. Above it, of course, on a gantry, some means of moving the huge forging from the furnace to a position for lowering are provided. The mouth of the well is covered by iron doors, which are closed as soon as the first evolution of gas has burnt. The lowering of so large a mass of red-hot steel as is represented by the greater forgings for the big guns into a comparatively small weight of fairly inflammable oil is not wholly unattended by danger; but, on the whole, few accidents have occurred, and it is only at the instant that the metal is being rapidly lowered into the oil that any flaring occurs. As soon as it is right in the doors are closed, and the oil boils away quietly. It may, however, be remarked that small hollow forging call for more care, and are more liable to produce accidents, than large forgings. This is due to the narrow bore of the small forgings, which is too contracted to allow the first bubbles of gas to escape. The consequence is that, if proper precautions are not taken, a quantity of flaming oil is shot up vertically out of the tube.

Two methods of heating and lowering the forgings into the oil tank are followed. In the first the tube or forging is heated on a steel frame truck with fire brick floor in a horizontal furnace. The truck is drawn out, and chains rapidly run through the tube and attached to a cross bar at the back. The front ends of the chains are attached to a larger chain, which passes over a pulley immediately over the oil well, and is commanded by a powerful hydraulic crane. The crane being put in action, the tube is first raised up into a nearly vertical position, and then allowed to swing gently, being controlled by chains attached to it, over the well and immediately rapidly lowered. The other method is to heat the forging in a vertical furnace provided with doors in its side. The furnace is entirely or partly above ground, the well is below ground, as we have said. It is, therefore, only necessary to open the doors of the furnace and lift the forgings a short distance, and traverse it till over the well, and then lower it. The second method seems to have many advantages over the first, but in actual practice the gain is not so great as would be expected. The time for the whole operation is nearly the same in both cases, and the inconvenience of luting the long door of the vertical furnace has to be considered. By partly sinking the furnace this trouble is reduced, and although we know of no case in practice, we see no reason why the whole length of the furnace should not be below ground, in which case the necessity for doors would be entirely removed. It is, however, doubtful if even by this means much time woule be saved, as the crane would have to make a long lift. The advocates of the horizontal furnace also contend that the forging is more evenly heated, a point of the utmost importance; but the vertical men refuse to acknowledge that as a fact, and make retort that in the horizontal system the forgings are always bent in raising them from the horizontal to the vertical position, to which the advocates of this system reply that a forging always bends when you heat it and cool it suddenly, no matter how it may be supported.

The vertical system is, however, rapidly gaining in favor, and is used by several makers on the Continent, and at Woolwich and elsewhere in this country. The furnace proper is made of boiler plate lined throughout with firebrick. It is placed within a second large cylinder of cast-iron, which is sunk in the ground. A crane is placed over the furnace in such a position that it has convenient command of both the oil well and furnace. The well is placed in close proximity to the furnace, and is almost entirely below ground. The large part of the furnace which is above ground is closed by doors, the joints of which are luted when the furnace is in service. The top is closed by a dished plate, lined also with firebrick, which can be run to one side on rails when it is required to raise the hot forging.

The furnace is heated by gas supplied from a Dowson's gas producer. The gas passes by pipes to a belt, which has a number of openings like the air belt. As soon as this gas will ignite and burn freely, the gas may be admitted to the furnace, and some lighted oily waste dropped down through the sight holes in the cover. The air is then gradually admitted, and the heat increased as required until the flame extends the whole height of the furnace, or as far up as required. An air pipe supplies air from a blower for assisting ventilation and keeping the pit cool. Ladders are provided for descending the pit. The temperature is regulated by the air slides, so as to enable a long tube to be uniformly heated throughout its length.

The effect of heating the steel, and thus cooling it rapidly, is, of course, considerably to increase its strength but to decrease its ductility. At the same time internal stresses are set up. With a view to keeping these as low as possible, consistently with the success of the operation, rape oil is used for cooling instead of water, its heat conductivity being lower, and the effect on the metal consequently neither so sudden or severe. The steel is nevertheless in a state unfit for use. To give it the necessary toughness, therefore, the forging has to be tempered. For some unknown reasons the process is called "annealing," or, for exactness, "second annealing," to distinguish it from the first similar operation after forging. The forgings are usually heated to about 900 degrees Fahrenheit to 1100 degrees, again depending on the first test, in closed furnaces, and are then allowed to cool out very slowly. At Woolwich this operation is also performed in a vertical gas heated furnace.

This furnace was designed from the suggestions of Mr. C. Turton, the manager of the Woolwich gunshops. No better method of heating than this could be desired. The forgings are enclosed in an oven to which the actual flame never penetrates, but which gradually and regularly increases in temperature. The steel is thus subjected to no uneven strains, and distortion does not ever occur.

In this country pyrometers for measuring the temperature in the furnaces are rarely employed, as an experienced operator is able to judge from the appearance of the forging what its temperature is within a sufficiently accurate limit. Only in the testing laboratory, as afterwards to be explained, an accurate pyrometer is used, so that the conditions of the test may be known absolutely.

—*The Engineer*, February 4, 1898.

* * * * *

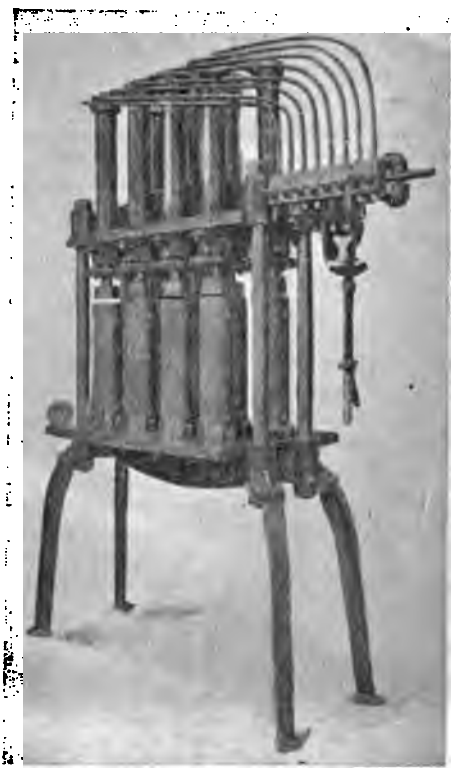
c. *Powder and Explosives.*

A Smokeless Powder Press.

The press shown in our illustration is one of several types of similar machines designed for the manufacture of smokeless powder, and made by the Watson Stillman Company, of this city.

Smokeless powder is manufactured into sticks of the caliber needed and cut off the right length to fill cartridges. These sticks contain from one to six holes for the entire length, according to the kind of powder that is used, and these presses are designed to take the powder in a plastic state and press it into sticks for use, and, in shop parlance, are called "squirting presses."

This particular press is an eight cylinder affair, made for the pressing of powder for small calibers. Each of the plungers is 2¼ inches in diameter, with a stroke of 10½ inches. The pressure is 3,000 pounds to the square inch,



exerting a total pressure of 12 tons on the material in the cylinders, forcing the same through the die at the bottom into a proper receptacle.

As will be seen the eight cylinders are controlled by one large multi-spindle valve operated by a lever, and each clylinder is provided, in the valve casing, with a separate controlling valve, throttling and governing its speed according to the condition of the materials, or cutting the cylinder out altogether.

Smokeless powder is rather precarious stuff to handle and will not stand very much abuse. This press provides for all emergencies that may arise. The powder may explode in one of these presses without very much damage; it automatically throws up the hydraulic ram.

In each head there is located a vacuum valve and an air valve. The latter is open except when closed by actual contact with material under the ram. If any air gets between the ram and powder, compression heats it and causes an explosion. On the other hand, the too sudden withdrawal of the ram will cause an explosion. Therefore a vacuum valve is provided.

On the sides of the cylinders, top and bottom, will be noticed cast lugs. They are for hooking in bales or handles for carrying the cylinders. The powder is put into the cylinder in a plastic state and kept there until pressed out as needed, the cylinders being taken to the press for this purpose. On the left hand of the table will be seen a die and die holder that go into the heavy plate under the cylinders.

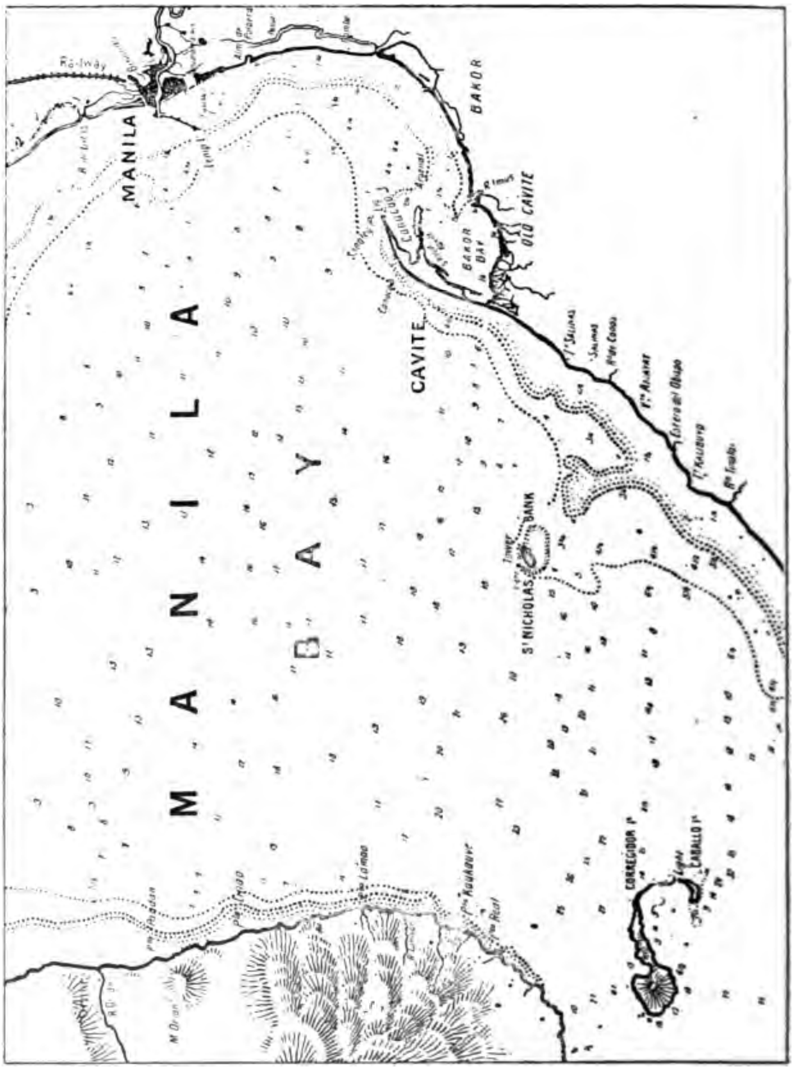
This machine is shown as a specimen of the work now going on in our machine shops on account of the activity of the War and Navy Departments.

—*American Machinist*, May 5, 1898.

TACTICS, STRATEGY AND MILITARY HISTORY.

The Hispano-American Struggle.

The prospect of an engagement between the squadrons of the United States and of Spain in the Philippines had hardly raised expectations before these were gratified. The result has been disastrous to the Spaniards, and in a measure it is to be feared from the accounts we have received that this is due partly to a lack of energy and foresight by the authorities at home and partly to want of skill by those engaged in the conduct of operations. Not only were the defences quite inadequate for the protection of the bay against the United States squadron, but the Spanish vessels appear to have been absolutely thrown away in the encounter. That the Spaniards fought bravely we make no doubt, but something more than bravery was required, and the Spanish narrative of what happened leads us to believe that they were no more a match for their enemy in point of professional ability than were they in regard to the relative strength of the naval forces at their disposal. The depth of water at the entrance to the bay in either channel precludes the idea of the use of submarine mines, but there would seem also to have been none of those obvious and essential precautions which should have been taken



in the circumstances. It does not appear that the southern entrance was defended in any way, and the forts, therefore, on Mariveles Point and Corregidor island were useless except to give notice, but not a sufficiently timely warning, of the impending attack. It seems almost incredible that there should have been no patrol at the entrance to the bay. The smaller Spanish vessels were suitable for this purpose, and doubtless there were other steam vessels at hand which might have been utilized with the same object. As we are told that Admiral Montojo had taken his squadron to sea a few days previous to the action we cannot suppose that he was insufficiently supplied with coal, yet we find four torpedo vessels, indeed five, which might have been used to attack an incoming enemy with a fair prospect of success, placed in a position where their powers of offence were largely neutralized. To anchor such vessels as those which comprised the Spanish squadron in an open bay, even though they might be partially protected by the fire of forts, was in the circumstances to invite disaster. The wording of the official telegram from the Governor-General of the Philippines to the Minister of War at Madrid gives us a notion of his ideas of defence, and presumably of those of his naval adviser as well. He says that the enemy's squadron "forced a passage under the obscurity of night"! What did he expect otherwise? He must have known that he had to deal with a bold and enterprising adversary, of whom it might have been predicted that he would act with decision and in the manner best adapted to his purpose. Admiral Dewey deserves the congratulations and honors which have been showered upon him for the thorough manner in which he carried out a boldly conceived and brilliantly executed enterprise.

At the time of writing we are wholly without trustworthy information as to the number and type of the guns mounted in the shore batteries at Cavite, although there are said to have been 10-inch and 12-inch guns placed there recently. Nor do we know the distance at which the Spanish ships were placed from the shore, or the range at which the Americans engaged. These and many more particulars are needed to make clear what took place, and for them we shall have to await a complete account from American sources. How unequal the battle was between the ships needs little demonstration. On the Spanish side not a ship was "protected," and it seems likely that the guns were equally without shields of any kind. The so-called "protection" of the torpedo gun vessels *Isla de Cuba* and *Isla de Luzon* merely consists of a 2.5-inch steel deck over the engine room and boilers; the *Reina Cristina* had been used as a transport, and it is stated that some of her guns had been removed. The *Castilla* and *Mindanao* were wooden vessels, and the *Velasco* little more than an armed merchantman, while the *Don Antonio de Ulloa* and the *Don Juan de Austria*, though fairly good gunboats for colonial work, were like all the rest entirely unfitted for a modern engagement with well protected vessels. We notice that the *Olympia* in some reports is described as an ironclad. This is not the case, but she is an exceptionally well protected cruiser, and, if not alone, was with the *Baltimore* and *Raleigh* quite a match for the whole scratch pack of Spaniards. The other American vessels, although less well protected, were nevertheless superior in point of armament to most of their antagonists. If we include nothing heavier than a 4.7 gun a comparison of the armaments of the two squadrons stands thus: United States—Ten 8-inch, twenty-four 6-inch, and ten 5-inch quick-firers; Spain—Thirteen 6-inch, twenty-four 4.7-inch. The thirteen 6-inch Spanish guns actually comprised six 6.3-inch Hontorias, three 6-inch Armstrongs, and four 5.9-inch Krupps.

The immense superiority in armament is obvious, and when it is remembered, moreover, that their ships and batteries were much better protected no surprise can be felt at the result of the action being in favor of the Americans. The unknown factor—the guns in the Cavite batteries—may have done some damage to the United States cruisers, but the destruction of the Spanish flotilla should have been a foregone conclusion. It is for this reason that we are of opinion that the proper use to have made of it was at the entrance to the bay and for a night attack. It is quite conceivable that some people will jump to the conclusion that this engagement shows the relative power of ships and land defences to have undergone a change. If they do they will make a mistake. Even if it were possible for armorclad ships to engage shore batterise without coming off second best it is quite certain that the so-called "protected" vessel is not fitted to be risked in such an encounter. It may be permissible for the sake of preventing the completion of a work to throw a few shells, as Admiral Sampson did at Matanzas, but even this must be done at long range.

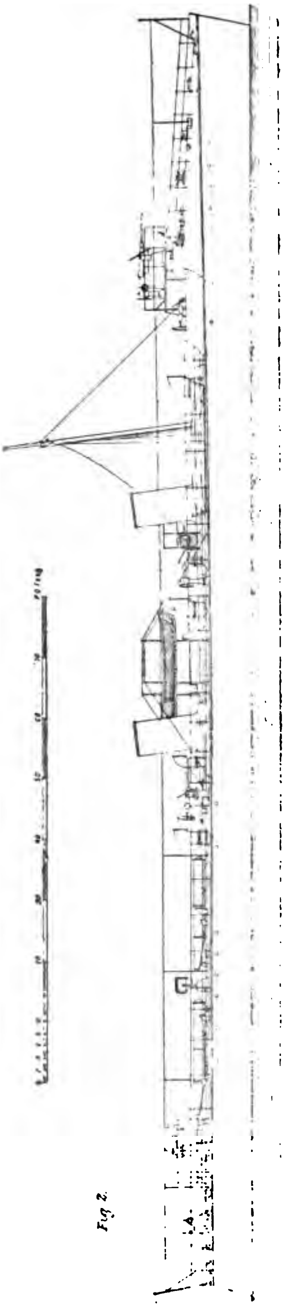
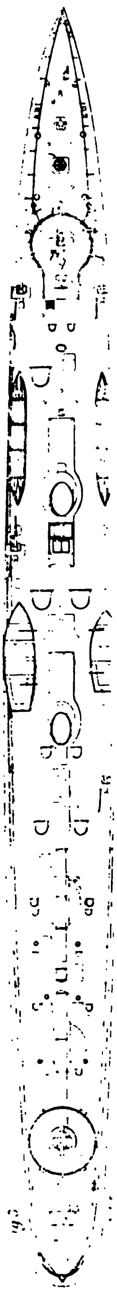


Fig. 2.



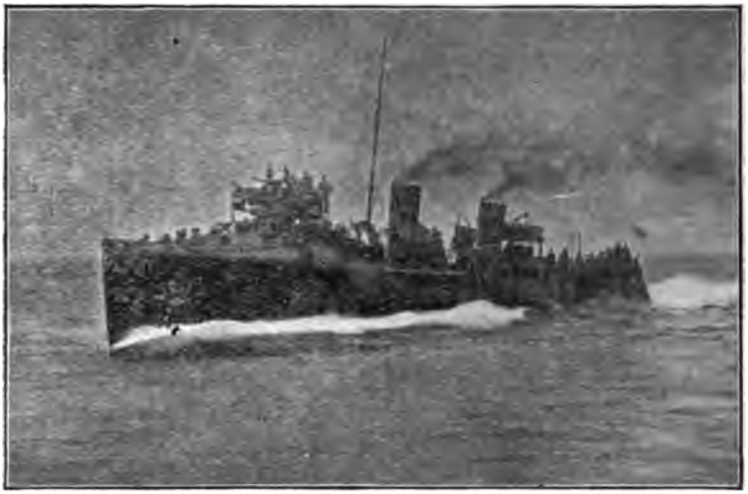
With regard to the situation in the Atlantic there has been very little definite information through the week. It would appear that both sides have now fully recognized the necessity for secrecy in regard to their movements. As we thought likely last week the departure of the Spanish squadron from Cape de Verde has had its effect, and we hear of a rearrangement and reconstitution of the blockading force. It was necessary, of course, to prepare a squadron which should be capable of meeting the Spaniards if they crossed the Atlantic. Whether the reports are true that instead of so doing this squadron has returned to Cadiz seems doubtful, although if such a move were made for the purpose of concentration, much might be said in its justification. In default of news the correspondents on the other side indulge in speculation, and opinion appears to be divided as to whether Admiral Sampson left Key West on Wednesday last for the purpose of meeting the *Oregon* or to escort an expedition for the capture of Porto Rico.

—*The Army and Navy Gazette*, May 7, 1898.

WAR-SHIPS AND TORPEDO BOATS.

H. M. S. "*Fame.*"

On the present and opposite pages we illustrate the torpedo-boat destroyer *Fame*, one of the recent and larger vessels of this type built to the order of the Admiralty by Messrs. J. I. Thornycroft and Co., of Chiswick. Fig 1 is a general view prepared from a very successful photograph taken when the vessel was running at high speed. Figs. 2 and 3, on the opposite page, are a profile view and a deck plan showing arrangement of armament, etc.



The *Fame* is 210 ft. long over all, the maximum beam being 19 ft. 6 in. and the depth 13 ft 6 in. In other respects she closely resembles the *Daring*, a vessel fully described in the columns on previous occasions.[*] The form of stern is that peculiar to the Thornycroft design, in which the after-part of the vessel is flattened under water, the propellers, of which there are two, being under the bottom. The engines are of the four-cylinder triple-compound type Messrs. Thornycroft have designed for vessels of this class, and which have been already illustrated by us[†] The engines of the *Fame* are, however, somewhat more powerful than those of the *Daring*, the cylinders being 20 in., 29 in., and two of 30 in. diameter, with a stroke of 18 in. There are three Thornycroft watertube boilers of the *Daring* type,[‡] but these are naturally somewhat larger than those of the latter craft, in order to give the increased power required for the higher speed of the larger vessel. There are three of these boilers, two being forward with a chimney in common, and one amidship with a single chimney.

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[*] See *Engineering*, vol lvi., page 674, and vol. lvii., page 850.

[†] See *Engineering*, vol. lviii., page 575.

[‡] The boilers of the *Daring* were illustrated in *Engineering*, vol. lvi., page 674.

The gun armament of the *Fame* is somewhat more powerful than that of the earlier vessels. There are five 6-pounder guns, two more than in the *Daring*. On the other hand, there are but two torpedo discharges, both of which are placed aft. The *Daring* had, in addition, a bow discharge, but the naval authorities consider this unnecessary for the later boats. No doubt in the arrangement of the armament the newer vessels more nearly fulfil the conditions suggested by the name of their class, and become more nearly torpedo-boat destroyers rather than torpedo-boats. There is, perhaps, some danger that an ambitious commander of these craft may turn his attention to small fry, and thus perhaps leave his larger consorts open to attack, to the frustration of the tactical plans of his Admiral. However, it would be a pity not to give the destroyers a chance to be useful in other fields than the distruction of torpedo-boats, which might not become an important factor in operations in progress. It will be the duty of the Admiral to keep his torpedo flotilia commanders well in hand, and any glory-hunting vagaries will have to be sternly dealt with, whatever their temporary success. This, of course, would not mean the destruction of all initiative on the part of separate commanders, when independent action could be undertaken without disobedience.

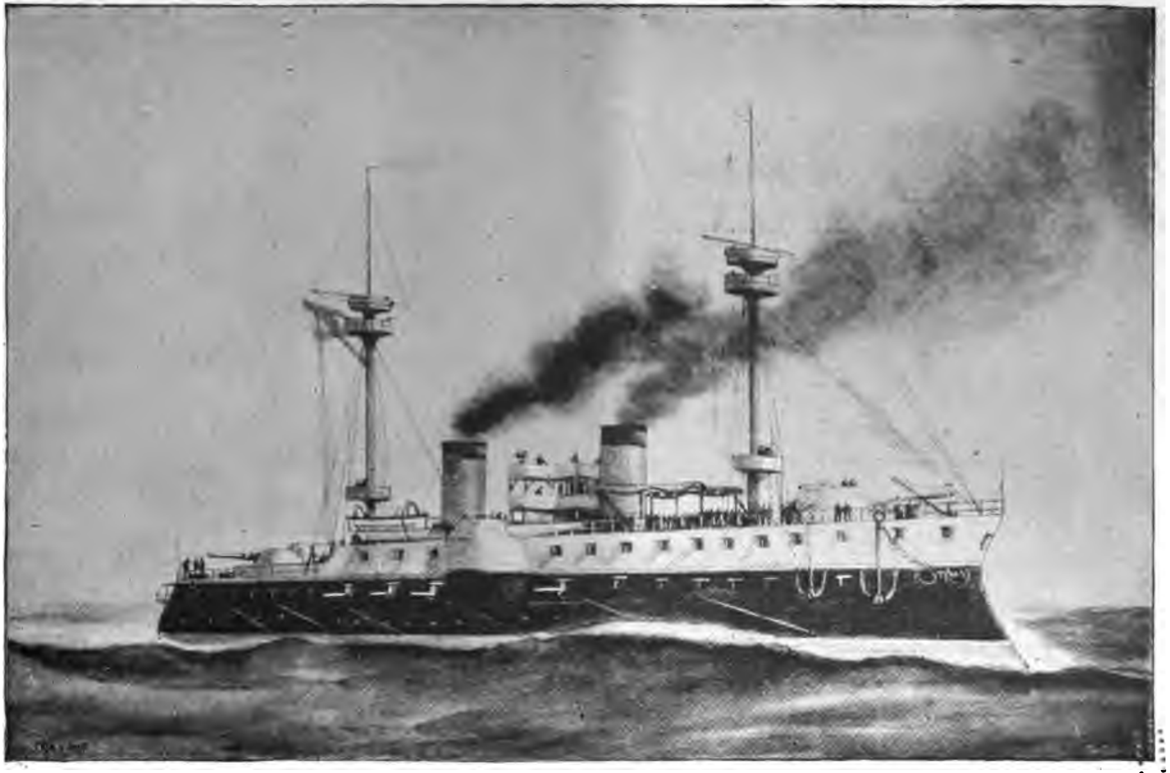
The *Fame* gave an excellent result on her trial trip, which was run on the Maplin measured mile. The draught forward was 5 ft. 1½ in.; aft, 7 ft. 1 in:; and the speed was 30.155 knots. The boiler pressure was 205 lb. per square inch:; the air pressure in the stokehold 4 in., and the vacuum averaged 26.3 in. The revolutions were 394.8 for the starboard, and 393.1 for the port engines. The mean indicated horsepower in the starboard engines was 2914, and in the port engines 2980, or a total of 5894 indicated horsepower for both sets of engines. The *Fame*, it will be seen, did not reach quite the speed attained by the *Desperate*, the latter vessel making on unofficial trial 30.46 and 31.035 knots, with a load of 15 tons on board in place of 35 tons: An account of the *Desperate's* trials was given in our issue of March 27, 1896.

—*Engineering*, December 31.

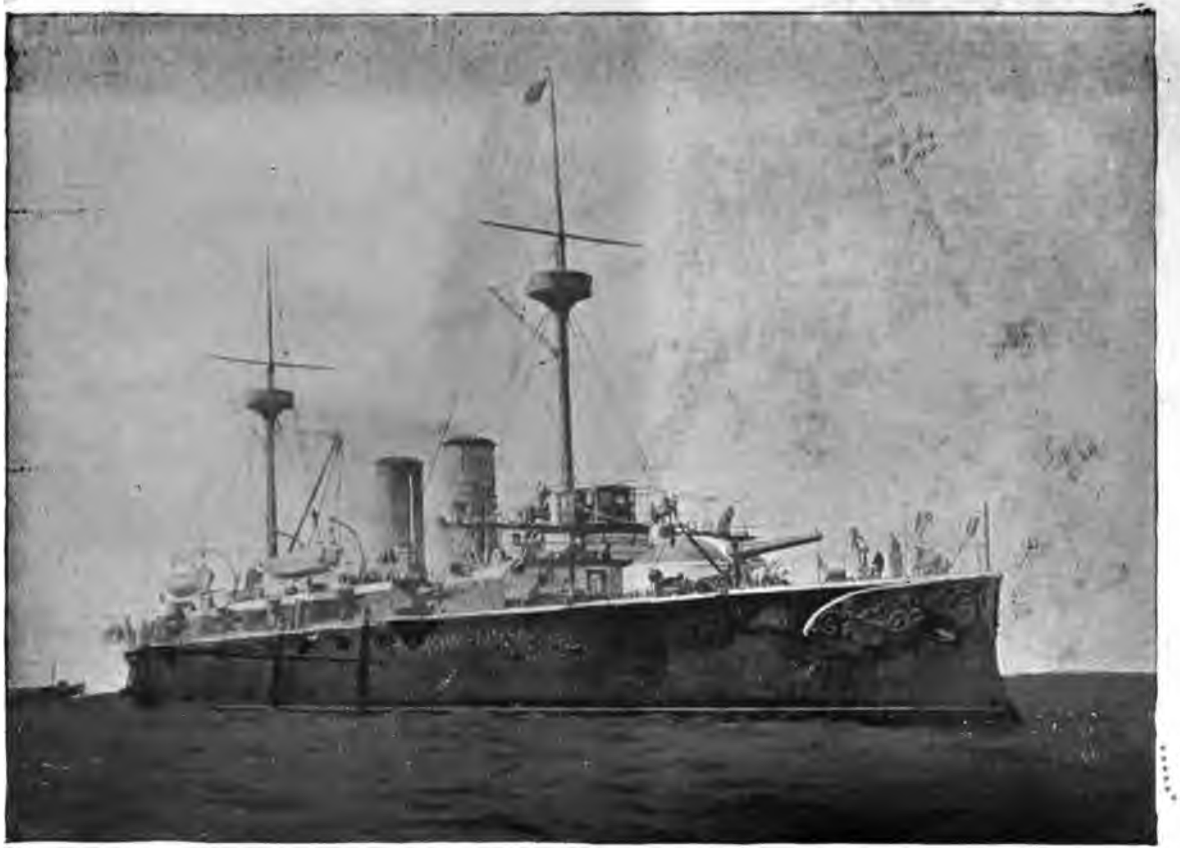
Spain's Naval Force.

In view of the probable outbreak of hostilities with the United States it may be interesting to give some details as to the naval forces Spain has available in the event of war.

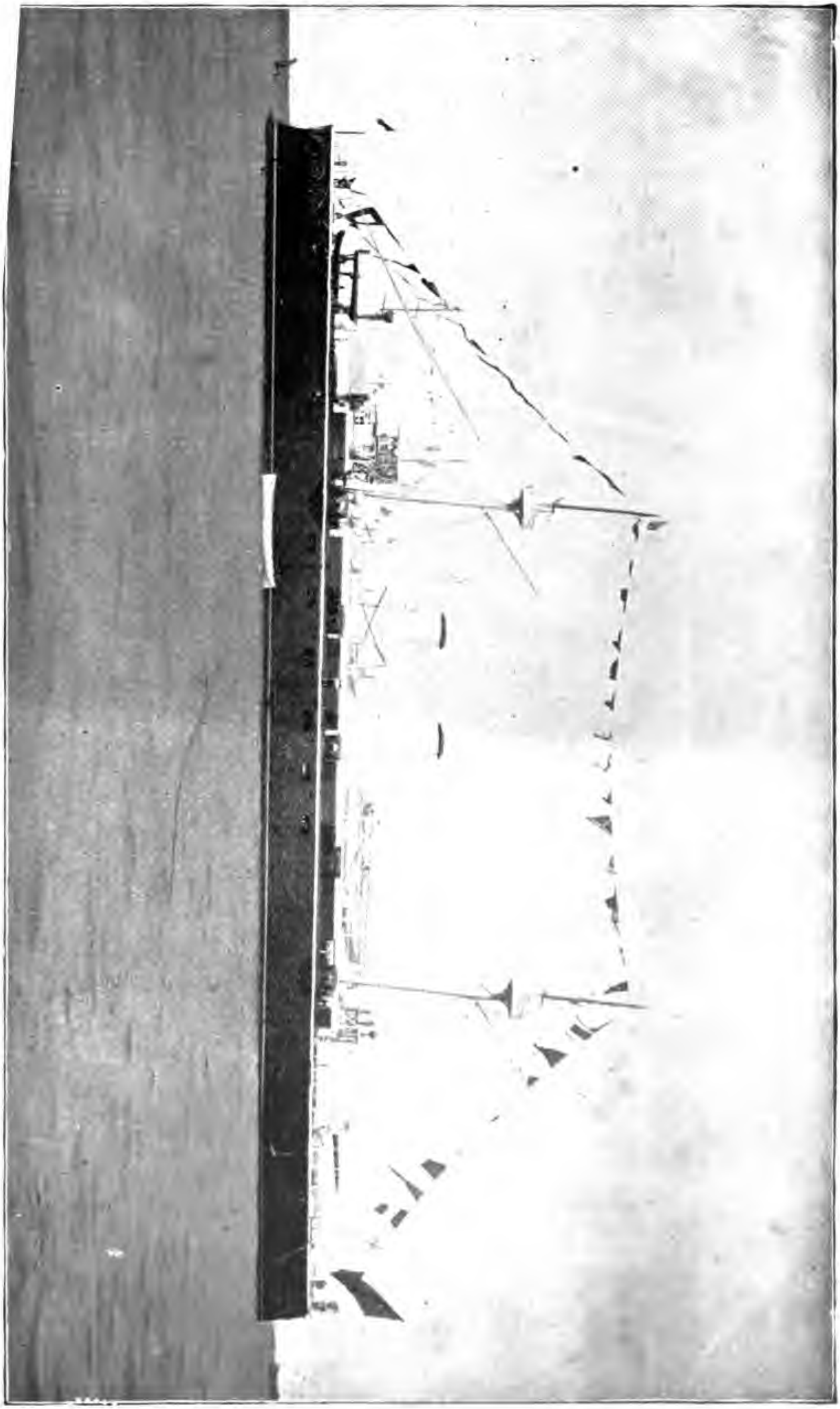
Her only battleship is the *Pelayo*, a vessel of 9,900 tons displacement, built in France at the La Seyne yard, near Toulon, and launched in 1887; she has lately undergone extensive repairs at the same yard, and Niclausse water-tube boilers have been substituted for her old cylindrical ones; she made 16 knots on her recent trial trip, and has since arrived at Cartagena. Protection is afforded by a complete water-line belt 17 inches in thickness, but tapering to 12 inches at the bow and stern, with two 15.7-inch transverse bulkheads, one forward and one aft, while there is a 4-inch armored deck. The armament consists of two 32-centimetre (12.5-inch) 48-ton Hontoria guns in armored barbettes, one forward and one aft; and two 28-centimetre (11-inch) 38-ton Hontoria guns, also in armored barbettes, one on each beam. All four turrets are protected by 18-inch armor with 6-inch steel hoods for the guns. The secondary battery now consists of nine 5.5-inch Q. F. guns, mounted one right forward and four on each beam in a central battery, with 20 small Q. F. and

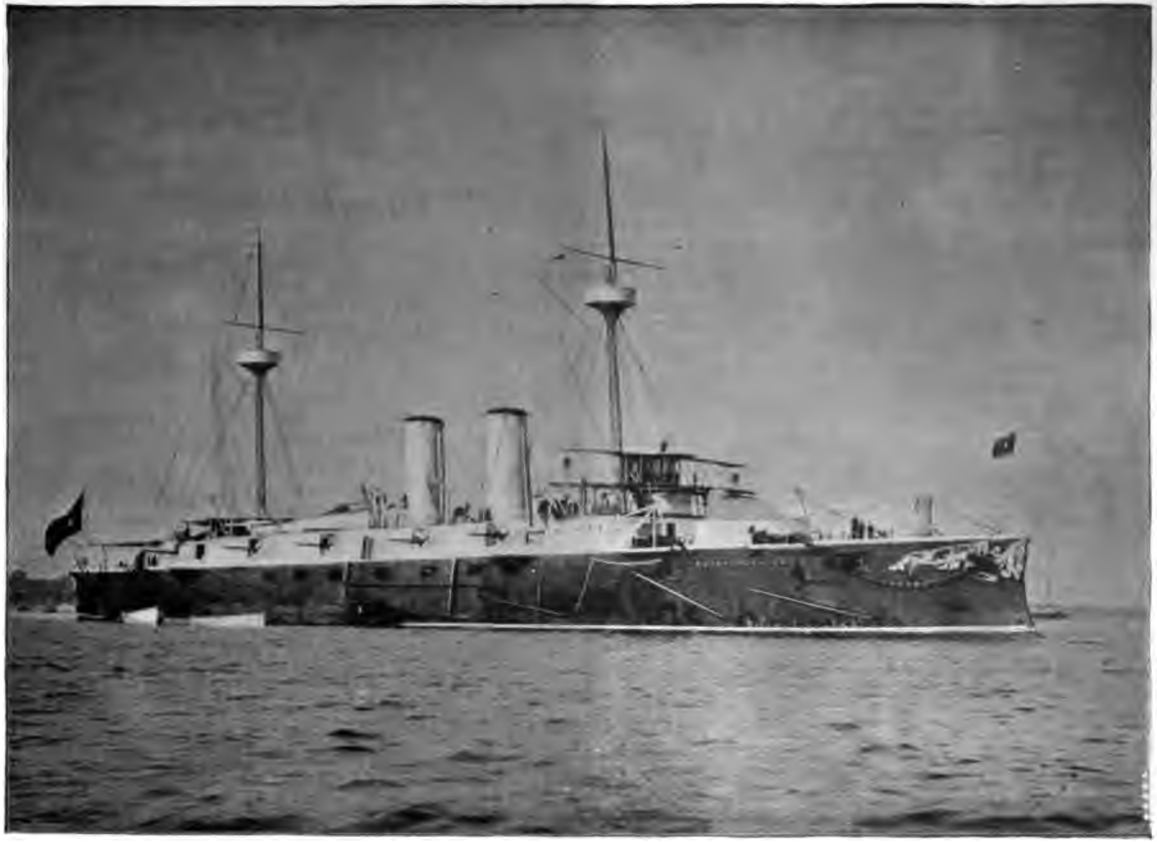


Pelayo.

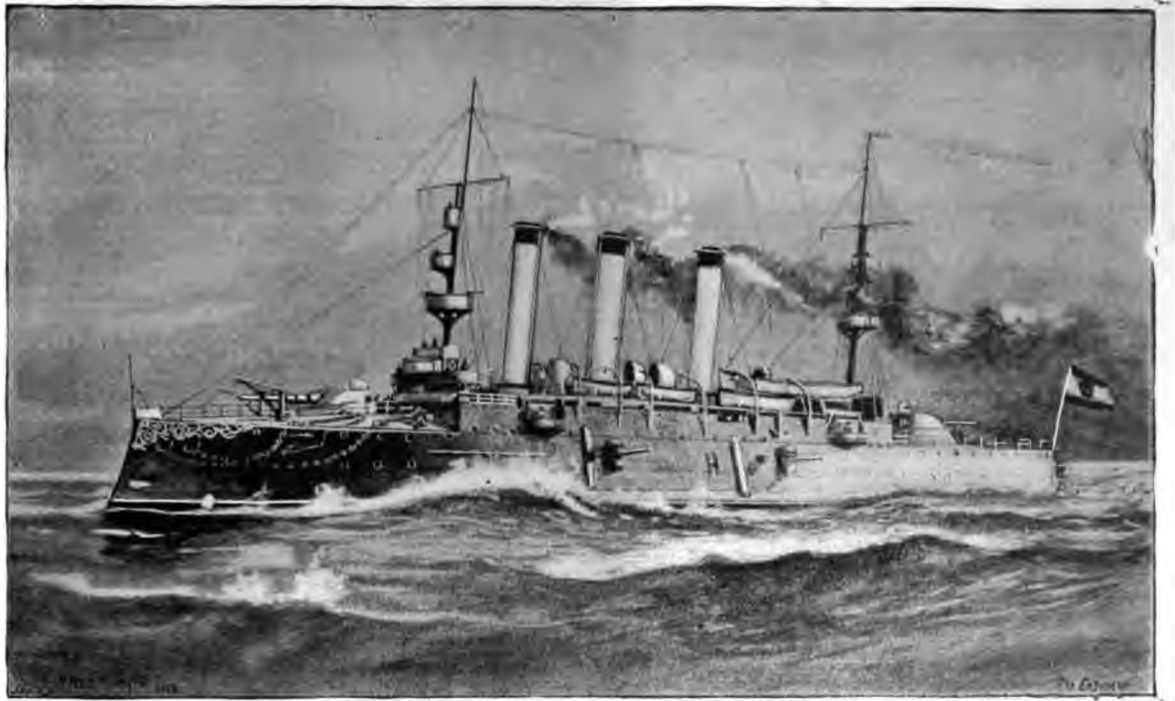


Vizcaya.





Infanta Maria Theresa.



Carlos V.

machine guns and 7 torpedo-tubes. The engines develop 9,000-I.H.P., giving the ship a speed of 16 knots, while the coal supply is 1,000 tons.

She possesses five powerful armored cruisers ready for sea, the finest being the *Cristobal Colon*, purchased last year from the Italian Government. This vessel has a displacement of 6,840 tons, with engines developing 14,000-I.H.P., giving a speed of 20 knots; protection being afforded by a 6-inch complete belt of hardened steel, above which is a central redoubt, 120 feet long, similarly protected, at each extremity of which are barbettes also with 6-inch plating, one forward and one aft, with 6-inch transverse bulkheads protecting their bases, a 10-inch gun with steel hood being mounted in each; in the redoubt are mounted ten 6-inch Q. F., and on the superstructure six 4.7 Q. F. guns, with 20 small Q.F. and machine guns; her coal capacity is 1,000 tons. The other four vessels are the *Vizcaya*, of which we give a photograph; *Infanta Maria Teresa*, *Almirante Oquendo*, and *Emperator Carlos V*. The first three are sister ships, vessels of 7,000 tons, with engines developing 13,000-I.H.P., giving a speed of 20 knots; they have a 12-inch belt, with 3-inch armor deck, and carry two 11-inch guns, one forward and one aft in barbettes protected by 10-5-inch armor, the guns being protected by hoods, while the secondary battery consists of ten 5.5-inch Q.F. guns, with 20 small Q.F. and machine guns and 8 torpedo tubes. The *Emperator Carlos V*, is of a somewhat different type, as she has no belt, but instead a 6.5-inch turtle-back armored deck, a central battery protected by 2-inch armor for her 5.5 inch Q.F. guns, the barbettes for her two 11-inch guns having 10.5-inch armor; her displacement is 2,000 odd tons larger, being 9,235, while her engines develop 18,500-I.H.P., but she is only credited with the same speed, viz., 20 knots. There are four other vessels of the *Viscaya* type under construction and completing, one of which—the *Princesa de Asturias*—is nearly ready for sea, and it is further reported that the Government have purchased the first-class armored cruiser *Varese* (a sister ship to the *Cristobal Colon*) from the Italian Government, but she will not be ready for sea for some time yet.

Of smaller cruisers of any value with speeds from 14 to 20 knots, Spain has 24, and of these the *Alfonso XII.*, a cruiser of 5,000 tons and engines of 11,000 I.H.P., with a speed of 20 knots, is the largest; but 11 out of the 24, it should be noted, are vessels of under 1,000 tons displacement, although they all have speeds varying from 18 to 20 knots; and she has, moreover, a powerful little flotilla of five 30-knot torpedo-boat destroyers, all lately completed by Thomson, of Clydebank. Although the Spanish navy is not likely to be able to effect much against the coast towns of the United States, defended as they will be by the powerful home defence fleet concentrated there, yet it ought to be able to do effective damage against the now considerable United States mercantile marine, especially as it is unlikely that any attack could be successfully made against the Spanish arsenals and seaport towns, from some of which their cruisers could undoubtedly operate against the United States trade routes.

—*Journal United Service Institution*, April, 1898.

Spain's Armored Cruisers.

The admission of vessels into the category of armored cruisers is governed so much by individual fancy that the term is in many cases very misleading. It might well be divided into at least three sub-heads, or else abolished altogether, for at present variations are so great that comparisons between ships designated as "armored cruisers" are well nigh impossible. There are cruisers, all called "armored," without any other distinction: (1) With armor on both guns and belt; (2) with armor on belt only; (3) with armor on the guns only. To the latter class the Spanish cruiser *Carlos V.* belongs, but as a general and quite unreasonable—rule, ships with armor for the guns only, like our *Powerfuls*, are classed as first-class protected cruisers, while a thin 3-inch belt will dignify them with the title of armored cruisers. If we compare the majority of Spanish cruisers, the *Vizcaya* and *Infanta Maria Teresa* class with their battleship *Pelayo*, we see that the sole difference between them is that where the *Pelayo* has a belt all round her, the *Vizcayas* have a partial belt for three-quarters of their length and bulkheads. The *Pelayo* has, of course, four big guns against their two, but then she is the bigger ship.

In both cases the guns are identically protected, a narrow barbette, with nothing below save an armored hoist. In each case a thin shield covers the gun breech—a foolish thing probably, since it is just sufficiently thick to burst a shell, and far too thin to keep anything out. Before *Yalu* the Chinese removed these shields from their battleships, and there was probably wisdom in so doing, though we must bear in mind that the Japanse have since replaced them in the *Chin Yen*. Probably, however, the new shields are of tougher armor, but on that no details are available.

We find, therefore, that to all intents and purposes the Spanish *Vizcaya* class are battleships of the second class, slightly armored, it is true, yet with more armor than the Italian *Lepanto* carries, since that "ironclad" has no belt at all. A vessel which—save that she has a 2-inch armor over the quick-fire guns—is identical to the Italian *Lepanto* in the arrangement of armor is the *Carlos V.* She has no belt, but a very thick deck—6-inch—her big guns in fore and aft barbettes alone are armored. The arrangement of guns is, of course, quite different to the *Lepanto's*, but the "idea" in both ships is similar. This idea is that a belt of coal and cellulose, with a thick deck below it, is quite equal to a heavy belt of armor. So far as protecting the engines goes this is true; and it *may* prove true in other ways. At the best, a belt is only a strip, liable to penetration above and below in a sea way.

The *Christobal Colon* could, and no doubt will, "lie in the line" if there is a naval action; she is proof against every sort of shell. Except her and the *Pedro d'Aragon*, now building, which carry 10-inch guns, all the Spanish armored cruisers carry a couple of 11-inch guns; very good pieces, able to penetrate all the armor on the American battleships' guns.

The American armored cruisers are quite different; they are really armored cruisers. Their belts, instead of being 12-inch steel as in the *Vizcayas*, are of 3-inch steel only; their big guns are only of 8-inch caliber. Now, an 8-inch projectile is quite useless against the belts of the *Vizcayas*, or against their barbettes, and in engaging such ships shell fire alone could be depended on to do anything. Of course, shell fire is the staple attack, but the *Brooklyn* and *New York* can do nothing against the Spaniards, with their comparatively feeble 8-inch shell, that the Spaniards cannot do against them with a far more powerful gun. It is rank heresy maybe, but we cannot but hold that there is a tendency to unduly glorify the small quick fire gun or the medium-sized 8-inch. The chances of hitting are, of course, greater with the smaller weapon, both from its extra rapidity and its extra numerical quantity; but when the big shot does hit its effect will be, of course, far greater. However, the *métier* of the Spanish and American armored cruisers is quite different, and it is profitless to compare them. Spain's force is really a number of second-class battleships—known as "armored cruisers"—and these will be pitted against a much smaller number of first-class American battleships. The "many eggs in one basket" is, when all things are considered, the best for battleships. America, therefore, apart from other considerations, should win. It is not very safe to prophesy anything, but the probabilities are either a "walk over" for one side, or else an absolutely indecisive but sanguinary result. There is not likely to be a mean between these extremes.

The other principal data with regard to the vessels referred to above, are as follows:—The *Vizcaya* is an armored cruiser, launched at Bilbao in 1891, carrying two 11-inch guns in two barbettes, and ten 5.5-inch guns, besides smaller weapons. Her displacement is 7000 tons, her length 340 feet, breadth 65 feet, and maximum draught 21 feet, 6 inches. She is propelled by twin screws, her engines developing 13,000 horse power. Her normal coal supply is large, namely, 1200 tons, sufficient to take her nearly 10,000 miles at 10 knots. Her maximum speed is 21 knots. With the exception of the *Pelayo*, she and the vessels of the same class are the most heavily armored in the Spanish navy. They have belt armor 12 inches thick, extending from bow to stern, but tapering off at the extremities; their big guns are protected by 10½-inch armor, and the deck plating is 3 inches thick. The *Infanta Maria Teresa*, also built at the same time and in the same yard, developes rather more power, but is armed and protected in the same way, and is of the same dimensions. Both ships have six torpedo tubes. The *Almirante Oquendo*, *Cataluna*, *Cardenal Cisneros*, and *Princessa de Asturias* are all very nearly the same in dimensions, and all carry the same guns and armor, so that these six ships form a valuable squadron, and as the slowest of them can steam 20 knots, they ought, if combined, be able to give a very good account of themselves.

The *Christobal Colon*, originally *Giuseppe Garibaldi II.*, is of rather less displacement—6840 tons—and indicates 14,000 horse power, but makes only the same speed as the *Vizcaya* class. Her main armament consists of two 10-inch guns and ten 6-inch, and six 4.7-inch and four torpedo tubes, so that she is powerful in this respect. She is protected by a 6-inch belt of Harveyed steel, and her guns are similarly provided. Her deck plating is 1½ inches thick. Her normal coal supply is 1000 tons. She was launched at Sestri Ponente in 1896.

—*The Engineer*, April 29, 1898.

The Spanish Warships *Carlos V.* and *Pelayo.*

The *Carlos V.* is one of those ships concerning whose details there is a considerable amount of doubt. According to "Brassey," who classes her as an armored cruiser, she is of 9235 tons, carries two Hontoria 11-inch guns in barbettes, plated with 10-inch steel, eight 5.5-inch quick-firers, four 3.9-inch quick firers, and six small quick-firers. The same authority gives her a 2-inch belt and a 6-inch deck. His plans of the ship, however, give her ten instead of eight 5.5-inch guns, and 17¾-inch armor on barbettes, a 2-inch skin over the entire amidships battery, but no deck. The "Naval Pocket Book" description accords mostly with this plan, but the tonnage is given as 9000, and the barbette armor 9.8-inch. "All the World's Fighting Ships" corresponds with the "Pocket Book" description, but gives fewer details. On the other hand, French papers speak of her positively as having a 6-inch belt; and when the ship was lying at Havre recently she looked to have a narrow belt for about one-third of the water-line amidship. The ship was then complete save for her big guns, and our illustration is from sketches and photographs taken of her then, about Christmas, 1897.

To look at, her arrangement of armament seems certainly similar to that of the *Edgar* class, saving always the fore-and-aft barbettes. These, like those of some Italian cruisers, do not correspond, the after one having the plates apparently set at an angle, while the forward one, which rises out of a slight turtle back, has vertical sides. Further details of the ship are: Length, 380 ft.; breadth, 67 ft.; draught, 25 ft. There is, unfortunately, no way of determining whether this is the mean or maximum draught. The maximum horse-power, forced draught, is 18,500, the trial speed 20 knots. The coal capacity —normal—is 1200 tons, but 600 tons extra can be stowed. She was launched at Cadiz in 1895, and in the ordinary course of Spanish shipbuilding would not have been completed for some two or three years yet. Her cost is reported at £750,000, £150,000 more than the *Vizcaya* class, which have a stout belt and an identical armament; 600 tons less coal capacity, 2000 tons less displacement, and 5000 tons less indicated horse-power in the case of *Vizcaya*, but very little less in the case of the *Cisneros*. Our *Blake* cost less than £450,000—roughly £50 a ton. Our *Undaunteds*, small *Vizcayas*, armed identically as the *Blakes*, cost about £50 a ton also. The cost of the *Carlos V.* works out at £83 a ton, of *Vizcaya* class £85 a ton. The *Carlos V.* has six above-water torpedo tubes, and probably two submerged tubes; but here again no really authentic information is obtainable.

The *Pelayo* was launched at La Seyne 11 years ago. She is of the same type as the French *Marceau*, having her four big guns disposed lonzenge-wise on the French system. This ship is of 9900 tons, with a complete 18-inch steel belt and 19-inch on the heavy gun positions. The protective deck on top of the belt is 3½-inch steel. The big gun hoists are 11.8-inch steel. The big guns are two 12.5 Hontorias, one forward and one aft, and an 11-inch Hontoria in each of the side barbettes. She has only recently left La Seyne, where a very complete refit has been partially carried out. Niclausse boilers have been fitted of 9000 indicated horse-power, in place of the old ones of 8000 indicated horse-power. The engines used to be vertical compound, and the screws two with four blades each. The maximum coal capacity was 800 tons, but she can probably stow 1000 now. The boilers are much lighter than the old. A reduction has been made in the secondary armament. It used to be one 6.2-inch breech-loader on the forecastle, twelve 4.7-inch breech-loaders on the main deck in an unprotected battery, one 3.5-inch breech-loader, and two 2.7-inch breech-loaders. The new armament, so far as one can gather, appears to be only eight 5.5-inch quick-firing Canet guns. "Brassey" gives nine 5.5-inch guns, and six smaller pieces. The saving in weight was to be applied to putting armor over the battery, bulkheads, and shields, but from all accounts only the latter had been fitted when she left La Seyne in consequence of the nearness of war. Being light, she will therefore be able to stow extra coal without undue submersion—an important thing, seeing how hampered for coal Spain is. There are seven above-water torpedo tubes.

—*The Engineer*, May 6, 1898.

The Spanish Cruiser *Vitoria*.

We have, on several occasions, called attention to the great work undertaken by the La Seyne works in transforming the Spanish frigates *Vitoria* and *Numancia* and increasing the fighting power of the *Pelayo*. Although differing greatly in value, these three vessels, for different reasons, constitute factors of great importance in the naval reorganization which Spain is now carrying on. The two first mentioned are to be entirely reconstructed, while the *Pelayo* will be simply improved by a change of boilers, involving an economy in weight.

The important changes to be made in these ships have been pushed with great energy. The *Vitoria*, already finished, left Toulon on March 1st for Carthagena, to take on board her new artillery. The *Pelayo*, which has just gone into dock at Toulon, after her trial there, has been put in condition to proceed to Spain with all dispatch. There only remains, then, the completion of the work on the *Numancia*, which is being carried on with the greatest energy.

The *Vitoria*, a photograph of which taken in Toulon is given herewith, is an armored frigate, launched in 1865 by the Thames Iron Works. Owing to progress of every kind, so many modifications in the construction of warships have been necessary in the thirty-three years since the *Vitoria* first saw the light, that it was hardly possible to make use of this old frigate without having her completely reconstructed. It is not without interest to notice, however, that in the *Vitoria*, as in the *Numancia*, built in France in 1863, the main characteristic of defensive power (having the whole hull completely armored) happens to be exactly in harmony with modern ideas applied quite recently to certain armored cruisers of various navies. As a result, the *Vitoria* and *Numancia* carry iron armor, varying in thickness from 14 to 11 cm. (5.5 to 4.3 inches) protecting all the freeboard of the ship up to the upper deck; the gun ports even are armored. This armor is covered with a layer of wood which conceals its nature, one quite formidable for the period in which the vessel was built.

The *Vitoria* possesses the following characteristics:

Length	316.50 feet.
Beam	56.89 feet.
Draught	24.00 feet.
Displacement	7250.00 tons.

Her sail area having been greatly reduced, the *Vitoria* possesses for motive power only a single screw driven by a low pressure engine made at the Penn works. This engine, capable of developing 4000 horse power, and of giving the vessel, under favorable conditions, a speed of 11 knots, is fed with steam from eight boilers of the Admiralty type, the fire tubes of which open into the two smoke-stacks. The old boilers have been replaced by eight new ones of the same Admiralty type.

But above all, the installation of new artillery and the results secured thereby constitute the most important improvement made in the vessel. The *Vitoria* was originally armed with eight 9-inch Armstrong guns, mounted broadside and throwing projectiles weighing 250 pounds; and three 7-inch (18 cm.) Palliser guns, one bow-chaser forward, and the two others amidships in the redoubt.

These pieces have been removed and arrangements made to receive the following pieces which have been since mounted on board in Spain:

1. Six 6.3-inch (16 cm.) guns, Hontoria system, distributed as follows: two forward in the bow, in the ports formerly existing there; two amidships, one on each side in the armored redoubt of the deck, on center-pintle carriages; two aft, one on each side in the upper deck in sponsons forward of the poop, mounted on center-pintle carriages and provided with revolving shields.

2. Eight 5.5-inch (14 cm.) rapid-fire broadside guns, Schneider-Canet system, placed four on each side in battery amidships, on center-pintle carriages and protected by revolving shields.

3. Six 2.24-inch (57 mm.) Nordenfelt rapid-fire guns, mounted on each side: two on the poop, two on a new bridge built across the middle of the ship, and two on the forecastle.

4. Six 1.45-inch (37 mm.) Maxim rapid-fire automatic guns: two mounted in the top on the foremast, two in the top on the mainmast, two in reserve for landing parties.

Magazines have been provided for the ammunition of all these new pieces. The service of the latter has been assured by suitable ammunition-lifts which are hoisted in conduits of iron by means of windlasses run by motors. There are twelve of these windlasses; four for the 16 cm. ammunition, four for the 14 cm. ammunition, two for that of the 57 mm. guns, and two for the service of the 37 mm. pieces.

These installations naturally have demanded a complete reconstruction of the interior with consequent change of all the parts that could not be utilized. The decks have been suitably reinforced at such places as was necessary.

The aspect of the ship has been completely modified by changing her masts, which used to be three in number, square-rigged. As is seen in the photograph, these have been replaced by two small metal masts, each carrying a top, one yard and topmast for signals. A new reduced sail area has been provided in consequence of this change.

When mention has been made of two directly coupled engines and dynamos, of 350 amperes at 80 volts, for furnishing the needed electrical energy, (lighting, projectors and signals) we will have given, in broad lines, the changes which now allow the *Vitoria* to figure once again in Spain's navy, the flag of which she has already borne so many years.

In spite of her speed, which is very inferior compared to that of present fighting units, the *Vitoria* could render very efficient service when demanded, on account of her most modern artillery and the large amount of protection she has.

—*Le Yacht*, April 2, 1898.

A. H. Jr.

GENERAL MILITARY MATTERS.

Kuropatkin: War Lord of Russia.

General Alexei Nicolaievitch Kuropàtkin, who was appointed acting minister of war on New Year's Day, is the greatest "fighting general" in the Russian army. He has won every distinction "for valor" in the field that the imperial crown holds in its gift; he has "swords of honor" enough to arm a company; he has seen active service in three continents—Africa, Europe, Asia—from Mount Atlas to Chinese Tartary; he was one of the decisive factors in the last great decisive battle fought on European soil. Further, General Kuropàtkin is the best writer of military history in Russia, the master of those who know in the science of war. In his forty-ninth year, and in the very prime of vigor and power, he is lord of the greatest army in the world—5,000,000 men in time of war. No finer augury could have been imagined for Russia's hopes in the new year and the new century than the destiny which calls this wisest warrior to lead the armies of the Czar.

In 1866 Alexei Kuropàtkin got his commission as sub-lieutenant in the Turkestan rifles, attracted thither by the voice of war. With the rank of lieutenant, Kuropàtkin returned to St. Petersburg to continue his studies in the science of war in the academy of the general staff. In those days the curled darlings of the most favored home of learning were nicknamed "pheasants" by the plain-plumed students of the other schools. They had favors at court balls, special opportunities for flirtation, and floods of social sunshine in that most distinguished metropolis. After the Turkish war they were called the "moments," because they so often sought and missed the psychological moment in a battle. If Lieutenant Kuropàtkin wore fine feathers, he worked hard. He completed his studies in 1874, coming out triumphant at the head of his year. The best student is annually rewarded. Lieutenant Kuropàtkin received a special allowance to continue his studies abroad. After a brief visit to Berlin he hurried on to Paris. Shortly after this Kuropàtkin was invited to take part in the maneuvers around Metz, where he showed such remarbable strategic ability that the French authorities enthusiastically made him *Officier de la Legion d'Honneur.* Alexei Kuropàtkin was thus the first Russian officer to receive this decoration for distinguished military services. From Metz the scene suddenly changes to Algiers, sacred to Tartarin and the Atlas lions. Kuropàtkin had better luck than the Tarascon hero. For eleven months he rode through the length and breadth of the land with a column under General Laverdeau, in the expedition of the Great Sahara, through the oasis of Mzab to Wargla.

From Algiers Kuropàtkin returned to the Norway winters and Persian summers of Turkestan. At this time Chinese Tartary was the hunting-ground of Yakub Bek of Kashgar, a man with something of Genghis Khan and Timur in him. Kuropàtkin was sent over the border into the wilds to find Yakub Bek and settle the frontier. Just round the corner of the Pamirs, near Osh in the Tian Shan mountains, his escort was set on by a swarm of Kara-Kirghiz nomads, the very material of conquering Tartar hordes. Alexei Kuropàtkin continued his journey through the wilds with a wounded arm and a stronger escort. He was among unknown deserts wilder than the Sahara. The expedition lasted a year, and 2,500 miles were covered on horseback. Kuropàtkin gained some diplomatic glory and wrote a book on Kashgaria, awarded the geographical society's gold medal, like the volume on Algiers.

For services in the Russo-Turkish war Colonel Kuropàtkin was awarded the golden sword of honor "for valor," and the crosses of St. Stanislav and St. Anne of the second class and St Vladimir of the third class, all with swords of honor. He is the only Russian general who holds the St. Stanislav and St. Anne crosses of the second class with swords of honor. "Lovcha, Plevna, Sheinovo," and "The Actions of General Skobeleff's Division" were added to the list of his writings. At the close of the war Kuropàtkin was appointed director of the Asiatic department of the general staff and joint professor of military statistics in the academy from which he had issued, as its most brilliant student, five years before. But he was not destined to enjoy long rest in the northern capital. There was trouble again on the borders of Turkestan, and Kuropàtkin was put in command of the Turkestan rifle brigade. At the siege of Geok Tépé, as commander of the right wing and afterward the center of the attack, the brunt of the battle fell on Kuropàtkin. The Turcomans were foemen worthy of the victors of Lovcha and Sheinovo. When in command of the chief storming column Kuropàtkin forced a way into the fortress by a brilliant piece of mining, and laid the foundations of a complete conquest of the Turcoman marauders--the last dregs of the great Mongol hordes. The cross of St. George of the third class and the rank of major-general record his doings in this Turcoman campaign. Then Skobeleff's sun set in a splendid carouse, to rise again in Valhalla.

From 1883 to 1890 General Kuropàtkin was busy with the work of the general staff, and played a leading part in that reorganization of the Russian army which marked the reign of Alexander III. This reorganization involved the application of the best and wisest modern standards throughout the whole army, which is now, in point of discipline, equipment, organization and knowledge, the equal of any in the world. In moral force, courage, and unity it is probably without equal. What remains to tell of Kuropàtkin's life up to New Year's day, when he became minister of war, is of high interest and value; though it can not compare, for stirring dramatic power, with what has gone before. On March 27, 1890, he was appointed governor of the Transcaspian province and promoted to the rank of lieutenant-general. It is admitted on all hands that the fruits of his rule show the wisdom of his appointment. He has completely pacified the Turcoman hordes, and carried far on the road to success that process of absorption which seems to be Russia's secret in dealing with Asian peoples. Contact with Russian rule seems to confirm and strengthen their national genius and steady them in the true path of their natural development.

All along General Kuropàtkin has steadily worked to strengthen the Russian colonizing element. And now, with the widest knowledge and experience to supplement his inherent genius and power, Alexei Nicolaievitch Kuropàtkin is called to the supreme post of power, the lordship of the Russian army, with its 5,000,000 men in time of war.

—*Public Opinion*, May 19, 1898.

Range Table for 4.7-inch (12-cm.) Q. F. Gun. Charge 8 lbs. 2½ oz.; Weight of Projectile 45 lbs.; Muzzle Velocity 2600 f.s.; Jump 3½ minutes to be subtracted from angle of departure.

By Major JAMES M. INGALLS.

Range.	Angle of Departure.		Five minutes elevation will alter range by	Five minutes will alter point of impact vertically at each range	Slope of descent.	Time of flight.	Remaining velocity.
yds.	°	′	yds.	feet.	one on	″	f.s.
100	0	2.5	202	1.7	1357.0	0.11	2555
200	0	5.0	197	2.0	665.4	0.23	2510
300	0	7.6	192	2.3	433.3	0.35	2466
400	0	10.3	188	2.6	317.8	0.47	2422
500	0	13.0	184	3.0	248.5	0.60	2379
600	0	15.8	179	3.4	202.2	0.73	2336
700	0	18.7	174	3.8	169.2	0.86	2294
800	0	21.6	170	4.2	144.5	0.99	2253
900	0	24.6	166	4.6	125.3	1.12	2212
1000	0	27.7	162	5.0	110.0	1.26	2171
1100	0	30.9	158	5.4	97.5	1.40	2131
1200	0	34.1	154	5.8	87.1	1.54	2091
1300	0	37.5	150	6.2	78.4	1.69	2052
1400	0	40.9	146	6.6	70.9	1.84	2014
1500	0	44.4	142	7.0	64.5	1.99	1976
1600	0	48.0	139	7.5	58.5	2.14	1939
1700	0	51.7	135	7.9	53.6	2.29	1902
1800	0	55.5	132	8.3	49.2	2.45	1865
1900	0	59.4	128	8.8	45.3	2.61	1829
2000	1	3.4	125	9.2	42.0	2.78	1794
2100	1	7.5	122	9.6	39.4	2.95	1760
2200	1	11.7	118	10.0	36.9	3.12	1726
2300	1	16.1	115	10.4	34.5	3.30	1693
2400	1	20.5	112	10.8	32.2	3.48	1660
2500	1	25.1	109	11.2	30.0	3.66	1628
2600	1	29.8	106	11.7	27.9	3.85	1596
2700	1	34.7	103	12.1	25.9	4.04	1565
2800	1	39.7	99	12.5	24.1	4.23	1535
2900	1	44.8	96	13.0	22.5	4.43	1505
3000	1	50.1	93	13.4	21.0	4.63	1476
3100	1	55.5	90	13.8	19.9	4.84	1447
3200	2	1.1	87	14.1	18.9	5.05	1419
3300	2	6.8	85	14.5	17.9	5.26	1392
3400	2	12.8	82	14.9	16.9	5.48	1366
3500	2	18.9	79	15.3	16.0	5.70	1340
3600	2	52.2	77	15.8	15.2	5.93	1315

RANGE TABLE FOR 4.7-INCH (12-cm.) Q. F. GUN.

Range.	Angle of Departure.		Five minutes elevation will alter range by	Five minutes will alter point of impact vertically at each range	Slope of descent.	Time of flight.	Remaining velocity.
yds.	°	′	yds.	feet.	one on	″	f.s.
3700	2	31.7	75	16.2	14.4	6.16	1291
3800	2	38.4	73	16.7	13.6	6.39	1268
3900	2	45.2	71	17.1	12.8	6.63	1246
4000	2	52.3	69	17.5	12.0	6.88	1225
4100	2	59.5	67	17.9	11.4	7.13	1205
4200	3	7.0	65	18.4	10.8	7.39	1186
4300	3	14.6	64	18.8	10.2	7.65	1169
4400	3	22.5	62	19.2	9.6	7.91	1152
4500	3	30.6	60	19.6	9.0	8.17	1136
4600	3	38.9	59	20.0	8.6	8.44	1122
4700	3	47.4	57	20.4	8.2	8.71	1108
4800	3	56.2	56	20.8	7.8	8.98	1095
4900	4	5.2	54	21.2	7.4	9.26	1083
5000	4	14.4	53	21.6	7.1	9.54	1071
5100	4	23.9	52	22.0	6.8	9.83	1060
5200	4	33.6	51	22.5	6.6	10.12	1049
5300	4	43.5	49	22.9	6.4	10.41	1039
5400	4	53.6	48	23.3	6.2	10.70	1029
5500	5	4.0	47	23.7	6.0	11.00	1020
5600	5	14.6	46	24.1	5.8	11.30	1011
5700	5	25.5	45	24.5	5.6	11.60	1003
5800	5	36.6	44	25.0	5.4	11.91	995
5900	5	47.9	43	25.4	5.2	12.21	987
6000	5	59.4	42	25.8	5.0	12.52	979
6100	6	11.2	41	26.2	4.8	12.83	972
6200	6	23.2	41	26.6	4.6	13.14	965
6300	6	35.4	40	27.1	4.4	13.46	958
6400	6	47.9	40	27.5	4.2	13.77	951
6500	7	0.6	39	27.9	4.0	14.19	944
6600	7	13.5	39	28.3	3.8	14.51	937
6700	7	26.7	38	28.7	3.6	14.83	931
6800	7	40.1	38	29.1	3.4	15.15	925
6900	7	53.7	37	29.5	3.2	15.47	919
7000	8	7.6	37	30.0	3.0	15.80	913

Range-table for 10-inch B. L. Rifle, steel. Service charge 260 lbs. brown prismatic powder. Projectile 575 lbs.; muzzle velocity, 2025 f. s.; tabular velocity, 2000 ± 50 f. s.

By Major JAMES M. INGALLS.

Range.	Angle of departure. φ	For $\Delta C = \pm \frac{1}{16} C$	For $\Delta V = \pm 50$ f. s.	Time of flight.	Drift.	Deviation for 10 miles of wind.	Fall		Maximum ordinate.	Striking velocity.	Penetration steel.
		Δφ ±	Δφ ∓				Angle of	Slope of			
Yds.	° ′	″	″	sec.	Yds.	Yds.	° ′		ft.	f. s	in.
1000	0 43.4	0.2	2.2	1.58	0.4	0.3	0 45	75.7	10	1869	18.8
1100	0 48.0	0.2	2.4	1.74	0.4	0.4	0 50	68.8	12	1856	
1200	0 52.6	0.3	2.6	1.90	0.4	0.4	0 55	62.	14	1844	
1300	0 57.2	0.3	2.9	2.07	0.5	0.5	1	56.8	17	1831	
1400	1 1.9	0.4	3.1	2.23	0.5	0.6	6	52.1	19	1819	
1500	1 6.7	0.5	3.3	2.40	0.6	0.7	11	48.4	22	1806	
1600	1 11.5	0.5	3.5	2.57	0.7	0.7	17	44.6	25	1794	
1700	1 16.3	0.6	3.8	2.73	0.7	0.8	23	41.4	29	1782	
1800	1 21.1	0.7	4.0	2.90	0.8	0.9	28	39.1	33	1770	
1900	1 26.0	0.8	4.3	3.07	0.9	1.0	34	36.6	37	1758	
2000	1 31.0	0.9	4.5	3.24	1.0	1.1	40	34.5	41	1746	17.1
2100	1 36.0	1.0	4.7	3.41	1.1	1.2	46	32.6	46	1734	
2200	1 41.0	1.1	5.0	3.58	1.2	1.3	52	30.9	51	1723	
2300	1 46.1	1.2	5.3	3.75	1.4	1.4	58	29.2	56	1711	
2400	1 51.2	1.4	5.5	3.93		1.5	2 4	27.8	61	1700	
2500	1 56.4	1.5	5.8	4.10	1.6	1.6	2 10	26.4	67	1688	
2600	2 1.6	1.6	6.0	4.28	1.8	1.7	2 17	25.	73	1677	
2700	2 6.9	1.8	6.3	4.46	2.0	1.8	2 23	23.9	79	1666	
2800	2 12.3	1.9	6.6	4.64	2.	1.9	30	22.8	86	1654	
2900	2 17.7	2.0	6.8	4.82	2.3	2.1	2 37	21.8	93	1643	
3000	2 23.2	2.2	7.1	5.00	2.5	2.2	44	20.9	101	1632	15.5
3100	2 28.7	2.3	7.4	5.18	2.	2.3	51	20.0	108	1621	
3200	2 34.3	2.4	7.6	5.37	2.9	2.5	58	19.2	116	1610	
3300	2 40.0	2.6	7.9	5.56	3.2	2.6	6	18.4	124	1600	
3400	2 45.7	2.7	8.2	5.74	3.4	2.8	3 13	17.7	133	1580	
3500	2 51.4	2.9	8.5	5.93	3.6	2.9	3 21	17.2	142	1578	
3600	2 57.2	3.1	8.7	6.12	3.9	3.1	3 29	16.4	151	1568	
3700	3 3.1	3.3	9.0	6.32	4.2	3.3	3 36	15.8	161	1557	
3800	3 9.0	3.5	9.3	6.51	4.4	3.5	3 44	15.2	171	1547	
3900	3 14.9	3.7	9.6	6.70	4.7	3.7	3 53	14.7	181	1536	
4000	3 20.9	3.9	9.9	6.90	5.0	3.9	4 1	14.3	192	1526	14.1
4100	3 26.9	4.2	10.2	7.10	5.3	4.1	4 9	13.8	203	1516	
4200	3 33.0	4.4	10.5	7.29	5.6	4.3	4 18	13.4	215	1505	
4300	3 39.2	4.7	10.8	7.49	5.9	4.6	4 26	13.0	226	1495	
4400	3 45.4	5.0	11.1	7.69	6.3	4.8	4 35	12.6	239	1485	
4500	3 51.7	5.3	11.4	7.90	6.6	5.1	4 44	12.2	252	1475	
4600	3 58.0	5.6	11.7	8.10	7.0	5.3	4 53	11.8	265	1466	
4700	4 4.4	5.9	12.0	8.31	7.4	5.6	5 2	11.4	279	1456	
4800	4 10.9	6.2	12.4	8.52	7.8	5.8	5 12	11.1	293	1446	
4900	4 17.4	6.5	12.7	8.73	8.2	6.1	5 21	10.7	307	1436	
5000	4 24.0	6.8	13.0	8.94	8.6	6.4	5 31	10.4	322	1427	12.8
5100	4 30.7	7.1	13.3	9.15	9.0	6.7	5 41	10.1	337	1417	
5200	4 37.4	7.4	13.6	9.37	9.4	7.0	5 51	9.8	353	1408	
5300	4 44.2	7.7	13.9	9.59	9.9	7.3	6 1	9.5	370	1399	
5400	4 51.1	8.1	14.2	9.81	10.3	7.6	6 11	9.3	387	1389	
5500	4 58.0	8.4	14.6	10.03	10.8	7.9	6 21	9.0	404	1380	
5600	5 5.0	8.8	14.9	10.25	11.3	8.2	6 32	8.7	422	1371	
5700	5 12.1	9.2	15.2	10.47	11.8	8.5	6 43	8.5	441	1363	
5800	5 19.3	9.6	15.6	10.70	12.3	8.8	6 54	8.2	460	1354	
5900	5 26.5	10.0	15.9	10.92	12.8	9.2	7 5	8.0	480	1345	
6000	5 33.8	10.4	16.3	11.15	13.4	9.5	7 16	7.8	500	1337	11.7
6100	5 41.2	10.8	16.7	11.38	14.0	9.8	7 27	7.6	521	1329	
6200	5 48.7	11.3	17.0	11.60	14.6	10.2	7 39	7.4	542	1321	
6300	5 56.2	11.7	17.4	11.83	15.2	10.5	7 51	7.2	564	1313	

RANGE TABLE FOR 10-INCH B.L. RIFLE (STEEL).

Range.	Angle of departure. φ		For $\Delta C = +\frac{1}{10}C$ $\Delta\phi$	For $\Delta V = +50$ f. s. $\Delta\phi$	Time of flight.	Drift.	Deviation for 10 miles of wind.	Fall Angle of		Fall Slope of	Maximum ordinate.	Striking velocity.	Penetration steel.
Yds.	°	′	″	″	sec.	*Yds.*	*Yds.*	°	′		ft.	f. s.	in.
6400	6	3.8	12.2	17.8	12.07	15.8	10.9	8	3	7.1	587	1305	
6500	6	11.5	12.7	18.2	12.30	16.5	11.2	8	15	6.9	610	1297	
6600	6	19.2	13.2	18.6	12.53	17.2	11.6	8	27	6.7	634	1290	
6700	6	27.0	13.7	19.0	12.77	17.9	11.9	8	40	6.6	657	1282	
6800	6	34.9	14.2	19.4	13.01	18.6	12.3	8	52	6.4	684	1275	
6900	6	42.9	14.8	19.9	13.25	19.3	12.7	9	5	6.2	710	1268	
7000	6	50.9	15.3	20.3	13.49	20.0	13.1	9	18	6.1	736	1261	
7100	6	59.0	15.9	20.8	13.73	20.7	13.5	9	31	6.0	763	1254	10.7
7200	7	7.1	16.4	21.3	13.98	21.5	13.9	9	45	5.8	791	1248	
7300	7	15.3	17.0	21.7	14.22	22.3	14.3	9	58	5.7	819	1241	
7400	7	23.6	17.6	22.2	14.47	23.1	14.7	10	12	5.6	848	1235	
7500	7	32.0	18.2	22.7	14.72	23.9	15.2	10	26	5.5	877	1229	
7600	7	40.5	18.8	23.2	14.97	24.8	15.6	10	40	5.3	908	1223	
7700	7	49.1	19.4	23.7	15.22	25.7	16.0	10	54	5.2	939	1217	
7800	7	57.7	20.0	24.2	15.48	26.6	16.5	11	8	5.1	971	1211	
7900	8	6.4	20.7	24.7	15.73	27.5	16.9	11	22	5.0	1004	1205	
8000	8	15.2	21.3	25.2	15.99	28.5	17.4	11	37	4.9	1037	1200	
8100	8	24.1	21.9	25.7	16.25	29.5	17.9	11	52	4.8	1071	1195	10.0
8200	8	33.1	22.6	26.2	16.51	30.5	18.4	12	7	4.7	1106	1190	
8300	8	42.1	23.3	26.7	16.78	31.5	18.8	12	22	4.6	1142	1185	
8400	8	51.2	24.0	27.2	17.04	32.6	19.3	12	37	4.5	1178	1180	
8500	9	0.4	24.6	27.7	17.30	33.7	19.8	12	52	4.4	1216	1175	
8600	9	9.7	25.4	28.3	17.57	34.8	20.3	13	8	4.3	1254	1170	
8700	9	19.1	26.1	28.8	17.84	35.9	20.8	13	24	4.2	1293	1166	
8800	9	28.5	26.8	29.3	18.11	37.1	21.3	13	39	4.2	1333	1161	
8900	9	38.0	27.5	29.9	18.38	38.3	21.8	13	55	4.1	1374	1157	
9000	9	47.6	28.3	30.4	18.65	39.5	22.3	14	11	4.0	1415	1153	9.4
9100	9	57.3	29.1	30.9	18.92	40.7	22.8	14	27	3.9	1457	1149	
9200	10	7.1	29.9	31.5	19.19	42.0	23.3	14	43	3.8	1500	1145	
9300	10	16.9	30.7	32.0	19.47	43.3	23.8	15	0	3.8	1545	1142	
9400	10	26.8	31.5	32.6	19.74	44.7	24.3	15	16	3.7	1590	1138	
9500	10	36.8	32.3	33.1	20.02	46.0	24.8	15	33	3.6	1636	1134	
9600	10	46.9	33.1	33.7	20.30	47.4	25.4	15	50	3.6	1683	1131	
9700	10	57.1	33.9	34.3	20.57	48.9	25.9	16	6	3.5	1731	1128	
9800	11	7.3	34.8	34.8	20.85	50.3	26.4	16	23	3.4	1779	1124	
9900	11	17.6	35.6	35.4	21.14	51.8	27.0	16	40	3.4	1829	1121	
10000	11	28.0	36.5	36.0	21.42	53.3	27.5	16	57	3.3	1880	1118	9.0
10100	11	38.5	37.4	36.6	21.70	54.9	28.0	17	14	3.2	1932	1115	
10200	11	49.1	38.2	37.2	21.99	56.4	28.6	17	31	3.2	1985	1112	
10300	11	59.8	39.1	37.8	22.28	58.1	29.2	17	49	3.1	2038	1110	
10400	12	10.5	40.0	38.4	22.57	59.7	29.7	18	6	3.1	2093	1107	
10500	12	21.3	40.9	39.0	22.86	61.4	30.3	18	24	3.0	2149	1104	
10600	12	32.2	41.9	39.6	23.15	63.2	30.9	18	42	3.0	2205	1102	
10700	12	43.1	42.8	40.2	23.44	64.9	31.4	18	59	2.9	2263	1100	
10800	12	54.1	43.7	40.9	23.74	66.7	32.0	19	17	2.9	2322	1097	
10900	13	5.2	44.7	41.5	24.03	68.5	32.6	19	35	2.8	2381	1095	
11000	13	16.4	45.7	42.1	24.33	70.4	33.2	19	53	2.8	2442	1093	
11100	13	27.7	46.7	42.7	24.63	72.3	33.8	20	11	2.8	2504	1091	8.7
11200	13	39.0	47.7	43.3	24.93	74.2	34.4	20	29	2.7	2566	1089	
11300	13	50.4	48.5	44.0	25.23	76.2	35.0	20	48	2.7	2630	1087	
11400	14	[illegible]	[illegible]	[illegible]	25.53	78.2	35.6	21	6	2.6	2695	1085	
11500	14	[illegible]	[illegible]	[illegible]	25.84	80.3	36.2	21	24	2.6	2761	1084	
11600	14	[illegible]	[illegible]	[illegible]	26.14	82.4	36.8	21	43	2.6	2828	1082	
11700	14	[illegible]	[illegible]	[illegible]	26.45	[illegible]	37.4	22	1	2.5	2896	1080	
11800	14	[illegible]	[illegible]	[illegible]	26.76	[illegible]	38.0	22	20	2.5	2965	1079	
11900	[illegible]	[illegible]	[illegible]	[illegible]	27.07	[illegible]	38.7	22	38	2.4	3036	1077	
12000	[illegible]	[illegible]	[illegible]	[illegible]	27.38	91.2	39.3	22	57	2.4	3107	1076	8.5

BOOK REVIEWS.

Lectures on Explosives. Willoughby Walke, First Lieutenant, Fifth United States Artillery Instructor U. S. Artillery School. Second Edition. New York: John Wiley & Sons. 1897.

The course of lectures prepared by Lieutenant Walke as a manual and guide in the practical laboratory work in the course of explosives at the U. S. Artillery School, has been officially adopted for the examination of officers of artillery for promotion, and so has received the stamp of authority. While most of the volume is compilation, the author has spared no pains in his description of processes of manufacture, to obtain the latest and fullest information on the subject, and in that respect the work is exceedingly satisfactory. The articles on densimetry, analysis of explosives and the service tests are all standard, and leave nothing to be desired. Certain improvements in the classification of explosives could be suggested, but as the author himself recognizes this fact, and has the changes under consideration, it is not necessary for us to make any remarks on that subject here.

The first point for criticism that would strike the chemical student familiar with the literature of the subject would probably be the excessive and free use made of Professor C. E. Munroe's *Lectures on Chemistry and Explosives*, Cundill's *Dictionary of Explosives*, and other works, and the slight acknowledgement made to these aids in compliation. Page after page, and even entire chapters, have been taken from Professor Munroe's work with the alteration of scarcely a word or a phrase, although some general remarks give this author credit therefor; and the description of a considerable number of explosives has been copied almost word for word from Major Cundill's work without any acknowledgement whatever.

The second point for criticism is the apparent looseness of the explanations of chemical actions in certain cases. We will consider the more important of these, in order.

It is but fair to state, however, that the author has corrected most of errors in the text at the beginning of the course with the class of officers, and we merely refer to them here in order to assist readers of the work.

P. 87, last paragraph: After the more or less full explanation of the principles involved in large-grained powders, it seems a little unfair to dismiss the action of perforated powders with the simple remark: "Perforations were found necessary to insure better and more uniform control of combustion in the grain," and without adding another word of explanation.

Page 99, paragraph three: The explanation of the effect of dissociation is really no *explanation* at all, and the whole paragraph had better be omitted. In the first place, it is very doubtful if the dissociation of water-vapor comes into play at all; and in the second place it is not necessary to consider it, because it can play but a secondary part, since water vapor decomposes only at a very high temperature and we know very little of the actual temperature in the bore of a gun, and still less of the temperature of dissociation of water vapor *under the pressure existing*. Moreover, there are other substances present (carbohydrates, for example) which decompose very readily, and their effect will far exceed that of water vapor.

Page 100, paragraph three: We fail to grasp the point which the author intends to make here. When carbohydrates are heated, besides the water vapor, compounds of carbon, hydrogen and oxygen are often given off, and some of these may contain a smaller proportion of hydrogen than is necessary to form water with the oxygen, consequently some hydrogen (still combustible) would be left with the carbon. But what has this to do with the explanation of the action of brown powders?

Page 155, last paragraph: The author does not appear to recognize the fact that, although in the nitrates only five-sixths of the oxygen is available for combustion, and in the chlorates all the oxygen is so available, nevertheless, a given weight of a nitrate furnishes *more* oxygen for combustion than the same weight of the corresponding chlorate.

Pages 105 and 106: In both structural formulæ the author gives us $C_{18} H_{26} O_{18}$, although he intends to give us the structural formula of $C_{18} H_{30} O_{15}$.

Page 297, paragraph two: The author *assumes* a reaction for the explosion of a mixture of guncotton and potassium nitrate, and then speaks of "the amount of guncotton required by theory," as if any theory had anything to do with it! Every variation in the proportions of the ingredients must occasion a change in the reaction of explosion.

Page 327, paragraph three: The fact that a smokeless powder gives off "noxious and irrespirable gases when exploded" certainly does *not* interfere with its use as a *military* explosive.

Pages 359 and 360: The explanation of the brusqueness of the action of pure mercury fulminate alone, as well as its action as compared with that of a mixture of the same with potassium nitrate, is entirely inadequate. The first is evidently due to the *rapidity of the chemical reaction*, which no one has as yet attempted to explain; the second may be explained by the fact that the particles of potassium nitrate *separate* the particles of the fulminate, and so dilute the latter and delay the chemical action. However, if dissociation does come into play (which is very doubtful, as far as explaining the difference in brusqueness is concerned) it will be the potassium carbonate, rather than the carbon dioxide, which will undergo this change.

Page 360, last paragraph: Defining diazo-benzene nitrate as "the residue of two nitrogenized bodies, etc.," is merely quoting a poor translation from the French, which does not fully bring out the original meaning. To any one who understands the general principles involved in explosive compounds the mere symbol would have shown the explosive character of the compound much better than the paragraph here referred to.

There are also a few minor points that call for remark:

Page 4, paragraph one: The velocity of propagation of the explosion of gunpowder in the open air is given as "4 feet per second," whereas Piobert (the authority usually quoted) gives it as *four-tenths of an inch per second.*

Page 168, paragraph five: The statement that "the nitro-compounds are less energetic in their action and more stable than the nitric ethers," is somewhat weakened by the reference, on p. 202, to "the greater stability and energy of nitric derivatives."

Page 215: The discussion of Vielle's formulas for the various grades of nitrocottons should inform the readers that his views have not as yet been generally accepted by the chemical world, indeed, most chemists still hold to Eder's views.

Page 285, last paragraph: What follows from this point on should have a new heading; as it stands it comes under the preceeding heading, with which it has nothing to do.

Lieutenant Walke's work is essentially a manual and guide for practical work in the laboratory, and the explanation of the phenomena of explosion is not a necessary part of it; still, as the author evidently regarded this as of some importance to the student, and therefore embodied it in his book, the latter should be clear and accurate in its statements relating to these phenomena.

We have been thus careful to point out small errors, which would hardly be noticed in a review ordinarily, because this work is a standard for the examination and instruction of officers, and for that reason all such errors should be eliminated. We point them out, not with any intention of merely finding fault but with a sincere desire to assist the author and publisher in improving their work, which has done excellent service in the laboratory of the Artillery School, and will be of great value to the army at large.

The general arrangement of the work is excellent, and the publishers have done their part well. J. P. W.

The Naval Annual, 1898. Edited by T. A. Brassey. Portsmouth: J. Griffin & Co., 2, The Hard.

This valuable publication, the best authority on the subject of the world's navies in the English language. appears once more and very opportunely. The special features of the present volume are an account of the Russian Navy, Sir George Clark's treatise on naval scouting, Commander Robinson's article on Naval Reinforcements in War Time, and Mr. Gleig's discussion of the question of food supply in war time.

The other information regarding the British navy and foreign navies is as complete and reliable as it can well be made.

The next number is to contain an account of the navy of the United States. What we have said in our review of the last volume (1897) applies, in general, to this, and we can only add that as a publication it becomes every year more indispensable to all navy and sea-coast artillery officers. J. P. W.

Petit Dictionnaire Militaire Français-Allemand et Allemand-Français par W. Stavenhagen. Première Partie: Français-Allemand. Berlin: Librairie Militaire de R. Eisenschmidt. 1897.

The ordinary dictionaries are quite inadequate for the military student in these days of enormous progress in all branches of military art and science, hence the necessity for a special work that shall take account of the vocabulary which this great development has added to literature of late years.

The little volume is intended primarily for the use of military men, but it will also find a welcome place in the library of the general reader, for the new words of technical military writers gradually creep into general literature.

The definitions are clear and concise, and the volume is printed and bound in convenient form for practical use. J. P. W.

Kriegsgeschichtliche Beispiele aus dem deutsch-französische Kriege von 1870-71. Kunz, Major a. D. Sechtes und Siebentes Heft. Berlin: E. S. Mittler und Sohn. M. 1.60 und 1.40.

The German field artillery, in 1870-1, established the principles on which are based our present ideas of the use of field artillery in battle. The two present numbers of this series of examples from the Franco-German war relate entirely to the use of field artillery, and since the German field artillery had a wide and varied experience, these examples are full of valuable lessons and interesting matter.

As an example of the modern method of massing artillery, the battle of Sedan was taken. Here 155 batteries were concentrated, of which 116 came into full action, 22 only partially (each firing less than 120 shots) and 17 did not fire at all. The entire artillery force available was, therefore, not required in bringing about a catastrophe such as no army had ever before suffered.

The surprise and attack of French camps by artillery is illustrated from the battles of Vionville, Amanvillers and Beaumont; and the part played by field artillery in the attack of French fortifications by instances taken from twenty-one different battles.

Important tactical questions, such as the near approach of the artillery to the enemy, the effect of flank fire and the weakness of the artillery flanks, and finally the preparation for the infantry attack on fortified positions or villages are illustrated and discussed in a thorough and masterly way.

Each of these numbers has appended a collection of problems based on the principles set forth and the situations cited.

As studies for the light artillery officer these example are invaluable, and we are pleased to note that the reception accorded to this collection by the military world has more than met the author's expectations.

J. P. W.

Die Heere und Flotten der Gegenwart. I. Deutschland. Herausgegeben von Professor Dr. J. von Pflugh-Harttung. Berlin: Schall und Grund.

A superb work, grand in design and elegant in execution. The interesting subject of the war power of Germany is presented in a most attractive form in this volume, and succeeding volumes will contain accounts of the other great armies and navies of the world, generally written by the most prominent men in the professions concerned. In the present volume the army is treated by Lieutenant-General v. Boguslawski, one of the foremost military writers of Germany, and the navy by Admiral Aschenborn of the Imperial German Navy. The authors are a guarantee of the excellence of the work, and since the publishers have spared no pains in making the illustrations as accurate and artistic as the subject-matter is interesting and reliable, the entire work stands unrivalled in the field it covers.

The account of the army opens with an historical introduction, then takes up the general military system, the organization of the army and its various branches, its mobilization, instruction, armament, equipment and clothing; continues with a spirited description of service in the army, an interesting and masterly summary of the changes in tactics to the present, an account of the service in the field and the attack and defence of fortifications and a description of the various military schools for officers and men; and closes with a full and accurate presentation of the medical, pay, quartermaster, commissary and other departments, and a brief essay on the moral factors in the army. To this are appended tables giving the constitution and location of all the subdivisions of the army.

The navy is pictured in a similar way.

The illustrations (many in colors) present the flags, uniforms, arms, guns, ships, bridge trains, and equipments, besides portraits of the most prominent commanders.

Altogether it is a book worth possessing by all who desire an acquaintance with the most perfect army the world has ever seen, and a navy that is fast attaining a high rank among the great navies of Europe.

J. P. W.

Recueil des Travaux Techniques des Officiers du Génie de l'Armée Belge. I. 1897. Ixelles: Inspector-General's Office.

Belgium has stood at the head of the profession of military engineering for a number of years, and General Brialmont still holds his place as the foremost military engineer of the world, while Captain Deguise, instructor in the course of fortification at the Brussels school of application, ranks high among the lesser lights.

The purpose of this collection of essays is to present the views of experts in various lines of thought for the benefit of the officers of the Belgian engineers. The publication committee is presided over by the Inspector-General of the army, and absolute freedom of thought is guaranteed. Articles by foreign engineer officers are also admitted.

The opening article is by General Brialmont on the organization of permanent intrenched camps, and it is not unteresting to note his introductory remarks:

"The advantages of and necessity for permanent intrenched camps has been recognized by the most distinguished generals and engineers of the century, and disputed by only a small number of critics, who have drawn false conclusions from the long resistance of Plevna and the destructive effects of torpedo shell. Hence, the subject is now limited to the consideration of the organization of intrenched camps, their character and the disposition of their works.

"Some engineers propose a girdle of forts without a central continuous enceinte, and cite in support of their proposition the intrenched camps of Reims, Epinal, Dijon, Bucharest and Copenhagen, constructed since the Franco-German war: but they lose sight of the fact, or deliberately ignore it, that the plans for the four first mentioned call for a closed interior work, but its construction has simply been postponed on account of the insufficiency of the appropriations, or from the necessity of meeting more urgent demands. The fifth, that of Copenhagen, is a peculiar case, as it is designed merely to resist a bombardment from the sea, either alone or combined with an assault by a landing party.

"As soon as the Danish government finds that the capital should be able to resist a regular siege, it will no longer hesitate to replace the old encenite, of which only the citadel is left, by a more extended enceinte forming a second line of defense."

The article discusses the subject in the author's usual masterly style, and with the two excellent plates illustrating it constitutes a little classic on the subject.

The second essay, by Captain of Engineers E. Cavelier, professor at the military academy, considers the relations of geology to the engineer's art. Other articles treat of the attack and defense of fortified places, the increased protection required in field fortifications, the rapid construction of mines, etc., and the volume closes with Captain Deguise's observations on the organization of the principal line of defense in fortresses of large development, another classic on the subject considered.

The plates leave nothing to be desired, and the entire work is a credit to this nation of military engineers.

J. P. W.

Descriptive General Chemistry, a text book for a short course, by S. E. Tillman, Professor of Chemistry, Mineralogy and Geology, United States Military Academy. West Point, N. Y., U. S. M. A. Press., 1897.

The appearance of a new text-book on chemistry, in view of the great number of such works already in use, seems to require some explanation.

The object of the course at the military academy is principally to teach so much of the subject as is necessary for the education of a gentleman, and secondarily to lay the foundation for the few who may be called upon in service to develop the subject further. Hence, the essential principles must first be establisned, and these must be followed by a description of the great chemical processes used in the world's manufactures. Now, no text-book combines these two in a satisfactory way to meet the demands of a course that is necessarily short, having in view the object above stated. Many are excellent on the subject of the principles of chemistry, and quite a number are sufficiently full on the applications to the arts and manufactures. The present work aims to combine the two in such a way as to meet the demands of the institution, the purpose of which is to prepare officers and not chemists.

"The matter embraced is the result of more than sixty years' selection and sifting made in the effort to secure that most essential and important for this course." (Preface).

The work is at present used only at the military academy, but when it is given to a publisher and made available elsewhere it should meet with a hearty welcome from all institutions in which the object is similar to that at West Point, viz: to give a general course of instruction in chemistry as a factor in general education. No better book for this purpose is in the market today.

J. P. W.

Die Lehre vom Schuss und die Schusstafeln. Heydenreich, Captain, Saxon Field Artillery Regiment No. 12, member of the Artillery Examining Board. Berlin: E. S. Mittler und Sohn. 1898. 6 marks.

This new work on artillery fire and range tables is the text-book in ballistics at the Artillery and Engineer School near Charlottenberg, and constitutes a supplement to the firing regulations of the artillery. In 1887 the separate sections of the old artillery manual were re-written and issued to the army as separate pamphlets. The author of the present work was detailed by the War Department to the Artillery Examining Board to write up the subject of ballistics. It is not designed to be a scientific treatise, but essentially a military handbook, consequently expressions involving the higher mathematics have been carefully avoided, in order to make the work accessible to all.

The book is divided into two parts, corresponding to the two years at the school of application above referred to. Part I contains the general principles at the foundation of the science, followed by a discussion of the subject of range tables, their arrangement, computation and practical use and value. Part II comprises the elements of interior and exterior ballistics.

The general principles contain nothing new, the purpose of this section being to refresh the memories of such officers as have not had occasion to study the subject of ballistics for some time.

The range tables are considered in a general way, taking up their purpose, their arrangement (with models of range tables for various projectiles), their practical use, with problems relating to deviation, the depth of action of shrapnel, the effects of torpedo shell, their computation, and finally their value in practice. An interesting section relates to firing at balloons and firing without *observing* the effects.

The subject of interior ballistics contains a very thorough discussion of the influence of size and form of grain, of space in which combustion takes place, of weight of charge, and of weight of projectile, on the rate of combustion, besides the influence of the mode of combustion on the accuracy.

Under exterior ballistics the usual matters are considered, and the work concludes with tables of the various factors of the ballistic tables, arranged for convenience in colors, the pages of each table having a different color, so that it can be quickly found.

J. P. W.

Der Kampf um Kuestenbefestigungen von Sigmund Mielichhofer, k. u. k. Hauptmann im Festungs-Artillerie-Regimente No. 5. Wien und Leipzig: Wilhelm Braumueller. 1897. 2 Mark.

This work is the first attempt to bring together in a single book all that is known and generally accepted on the subject of the defensive organization of sea-coast forts, their attack and defense.

The author (a Captain in the Austrian Fortification Artillery) has devoted much time and study to the subject, and the articles he has published from time to time have been well received.

The lack of a good and complete work on this subject has prevented many officers from applying themselves to the study of the questions involved, questions that are of vital importance to the artillery, and one of the purposes of the present volume is to overcome this difficulty.

The author discusses first the *value* of sea-coast fortifications, and then takes up the *means* of attack and defense, including, first, those common to both: such as the floating material, the ram, artillery, the torpedo, the torpedo net, the search light, etc.; second, the special means for defense: such as sea-coast artillery, fortifications, range finders, obstructions, the electric light, etc.

After a short discussion of the preparations necessary for coast defenses, illustrated by an example of an actual harbor properly prepared for defense, with all the accessories, the author considers the different modes of attack, viz: blockade, bombardment and attack by sea, the last comprising the removal of the outer obstructions, reconnoitering the artillery of the defense, attack by artillery on the works protecting the entrance, reconnoitering and removing the inner obstructions, and the forcing of the entrance. The illustrations are the forcing of the entrance to the Mississippi in 1862, and to Mobile Bay in 1864, both of which are still models for the action of the world's navies, as shown by Commodore Dewey's splendid action at Manila.

Landing operations are next considered, and these are illustrated by Wei-hai-Wei in 1895.

The consideration of the measures of the defense against these different modes of attack forms the closing chapter of the work.

The subject-matter is treated with great clearness, conciseness, system and thoroughness, and the entire work is worthy of careful study by the artillery officer.

J. P. W.

BOOK NOTICES.

[These books will be fully *reviewed* as space becomes available.]

Der deutsche Besitz in Schantung von H. von Bülow, Leipzig: Verlagsanstalt Militärische Rundschau. 1898.

The Engineering Magazine. New York: 120 Liberty street.

We desire to call special attention to the *Engineering Index* of this valuable publication.

Catechismal Edition of the Infantry Drill Regulations United States Army. Extended Order. Prepared by Major Wm. F. Spurgin, 23rd Infantry. Kansas City, Mo.: Hudson-Kimberly Publishing Co. Price: Tag board cover, 25 cents, blue cloth, 50 cents.

Privates' Handbook of Military Courtesy and Guard Duty by Lieut. Melvin W. Rowell, United States Army. Kansas City, Mo.: Hudson-Kimberly Publishing Co. Price: Tag board cover, 25 cents, blue cloth, 50 cents.

Manual for Cyclists for the use of the Regular Army, Organized Militia, and Volunteer Troops of the United States. By Captain Howard A. Giddings, Brigade Signal Officer, Connecticut National Guard. Kansas City, Mo.: Hudson-Kimberly Publishing Co. Price: Full blue cloth, illustrated, 75 cents.

Inquiries into the Tactics of the Future. Fritz Hoenig. Translated by Carl Reichmann, First Lieutenant, 9th Infantry. International Military Series, No. 6. Kansas City, Mo.: Hudson-Kimberly Co. Price: Full blue cloth, $2.00.

INDEX TO CURRENT ARTILLERY LITERATURE.

PERIODICALS CITED.

Abbreviations employed in index are added here in brackets.

All the periodicals are preserved in the Artillery School Library, Fort Monroe, Virginia.

ENGLAND.

Aldershot Military Society. *Occasional.*
Aldershot. Copies 6d each.

Arms and Explosives. [*Arms and Ex.*] *Monthly.*
Effingham House, Arundel Street, Strand, London, W. C. Per year 7s.

Army and Navy Gazette. [*A. and N. Gaz.*] *Weekly.*
3 *York Street, Covent Garden, London. Per year £1* 12*s* 6*d.*

Canadian Military Gazette. [*Can. Gaz.*] *Fortnightly.*
Box 2179 *Montreal, Canada. Per year* $2.00.

The Engineer. [*Eng.*] *Weekly.*
33 *Norfolk Street, Strand, London. Per year £2 6d.*

Engineering. [*Eng'ing.*] *Weekly.*
35-36 *Bedford Street, Strand, London, W. C. Per year £2 6d.*

Journal of the Royal United Service Institution. [*Jour. R. U. S. I.*] *Monthly.*
17 *Great George Street, London, S. W. Per year* 24 *s.*

Journal of the United Service Institution of India. [*Jour. U. S. I. India*] *Quarterly.*
Simla, India. Per year $2.50.

Photographic Journal. [*Photo. Jour.*] *Monthly.*
12 *Hanover Square, London.*

Proceedings of the Institution of Civil Engineers. [*Proceedings I. C. E.*]
25 *Great George Street, Westminister, London.*

Proceedings of the Institution of Mechanical Engineers.
[*Proceedings I. M. E.*] 19 *Victoria Street, Westminister, London.*

Proceedings of the Royal Artillery Institution. [*Proceedings R. A. I.*] *Monthly.*
Woolwich, England.

Professional Papers of the Corps of Royal Engineers.
[*Prof. Papers Corps Royal Eng'rs.*]
Chatham, England.

Review of Reviews. [*Rev. of Rev. Austral.*] *Monthly.*
169 *Queen Street, Melbourne, Australia. Per year* 11 s. 6 d.

Transactions of the Canadian Institute. [*Trans. Canadian Inst.*]
58 *Richmond Street, Toronto, Canada.*

Transactions of the Canadian Society of Civil Engineers.
[*Trans. Canadian Soc. C. E.*]
Montreal, Canada.

Transactions of the East of Scotland Tactical Society.
[*Trans. E. of S. Tactical Soc.*]
51 *Hanover Street, Edinburgh, Scotland.*

Transactions of the Institute of Naval Architects.
[*Trans. Inst. Naval Architects.*]
5 *Adelphi Terrace, London, W.C.*

United Service Gazette. [*U. S. Gaz.*] *Weekly.*
4-6 *Catherine Street, Strand, London, W. C. Per year £*1 10*s* 6*d.*

FRANCE.

L'Avenir Militaire. [*Avenir.*] *Semi-weekly.*
13 *Quai Voltaire, Paris. Per year* 18 *Fr.*

Le Génie Civil. [*Génie C.*] *Weekly.*
6 *Rue de la Chaussée d'Antin, Paris. Per year* 45 *Fr.*

Journal des Sciences Militaires. [*Sciences Militaires.*] *Monthly.*
Rue et Passage Dauphine 30, *Paris. Per year* 40 *Fr.*

La Marine Française. [*Marine F.*] *Semi-monthly.*
23 *Rue Madame, Paris. Per year* 30 *Fr.*

Mémoires et Compte Rendu des Travaux de la Société des Ingénieurs Civils.
[*Ingénieurs Civils.*] *Monthly.*
10 *Cité Rougemont, Paris. Per year* 36 *Fr.*

Mémorial des Poudres et Salpêtres. [*M. Poudres et S.*] *Quarterly.*
Quai des Grands-Augustins, 55, *Paris. Per year* 12 *Fr.*

Le Monde Militaire. [*Monde.*] *Fortnightly.*
76 *Rue de Seine, Paris. Per year* 6 *Fr.*

Revue d'Artillerie. [*R. Artillerie.*] *Monthly.*
5 *Rue des Beaux-Arts, Paris. Per year* 22 *Fr.*

Revue de Cavalerie. [*R. Cav.*] *Monthly.*
Berger Levrault et Cie, Rue des Beaux-Arts 5, *Paris. Per year* 33 *Fr.*

Revue du Cercle Militaire. [*Cercle.*] *Weekly.*
37 *Rue de Bellechasse, Paris. Per year* 27 *Fr.*

Revue du Génie Militaire. [*Génie M.*] *Monthly.*
8 *Rue Saint-Dominique, Paris. Per year* 27 *Fr.*

Revue d'Infanterie. [*R. Inf.*] *Monthly.*
11 *Place Saint André-des-Arts, Paris. Per year* 25 *Fr.*

Revue Maritime. [*R. Maritime.*] *Monthly.*
L. Baudoin, Rue et Passage Dauphine 30, *Paris. Per year* 56 *Fr.*

Revue Militaire de l'Etranger. [*Etranger.*] *Monthly.*
L. Baudoin, Rue et Passage Dauphine 30, *Paris. Per year* 15 *Fr.*

Revue Militaire Universelle. [*R. Univ.*] *Monthly.*
11 *Place Saint André-des-Arts, Paris. Per year* 25 *Fr.*

Le Yacht—Journal de la Marine. [*Yacht.*] *Weekly.*
55 *Rue de Chateaudun, Paris. Per year* 30 *Fr.*

GERMANY.

Allgemeine Militaer-Zeitung. [*A. M.-Zeitung.*] *Semi-weekly.*
Darmstadt. Per year 24 *M.*

Archiv fuer die Artillerie-und Ingenieur Offiziere. [*Archiv.*] *Monthly.*
Koch Strasse, 68-78, *Berlin*, *S. W.* 12. *Per year* 12 *M.*

Beiheft zum Militaer-Wochenblatt. [*Beiheft.*]
Koch Strasse, 68, *S. W.*, *Berlin.*

Deutsche Heeres-Zeitung. [*Heeres-Zeit.*] *Semi-weekly.*
Wilhelmstrasse 15, *Berlin. Per year* $6.00.

Internationale Revue. [*Int. Revue.*] *Monthly.*
Blasewitzer Strasse 15, *Dresden. Per quarter* 6 *M.*

Jahrbuecher fuer die deutsche Armee und Marine. [*Jahrbuecher.*] *Monthly.*
Mohren Strasse, 19, *Berlin*, *W.* 8. *Per year* 32 *M.*

Kriegstechnische Zeitschrift. [*Kriegstech.*] *Ten numbers a year.*
Koch Strasse, 68-71, *Berlin. Per year* 10 *M.*

Kriegswaffen. [*Kriegswaffen.*] *Monthly.*
Rathenow, *Germany. Per year* $4.50.

Marine Rundschau. [*Mar. Rundschau.*] *Monthly.*
Koch Strasse, 68-70, *Berlin. Per year* 3 *M.*

Militaer-Wochenblatt. [*Wochenblatt.*] *Semi-weekly.*
Koch Strasse, 68, *Berlin*, *S. W.* 12. *Per Year* 20 *M.*

Militärische Rundschau. [*Mil. Rundschau.*] *Occasional.*
Zuckschwerdt & Co., *Leipzig. Per quarter* 4.75 *M.*

Stahl und Eisen. [*Stahl u. Eisen.*] *Fortnightly.*
Schadenplatz 14, *Düsseldorf. Per year* $5.00.

Umschau, Die. [*Umschau.*] *Weekly.*
Frankfort a. M. Per year 10 *M.*

AUSTRIA.

Mittheilungen ueber Gegenstaende des Artillerie und Genie-Wesens.
[*Mitth. Art. u. G.*] *Monthly.*
Wien, *VI*, *Getreidemarkt* 9. *Per year* 1 *Fl.* 50 *Kr.*

Mittheilungen aus dem Gebiete des Seewesens. [*Seewesens.*] *Monthly.*
Pola. Per year 14 *M.*

Organ der Militaer Wissenchaftlichen Vereine. [*Vereine.*]
Wien I, *Stauchgasse No.* 4. *Per year*, 8-14 *numbers*, 6 *Fl.*

Zeitschrift des Oesterreichischen Ingenieur und Architekten Vereines.
[*Z. Architekten Vereines.*] *Weekly.*
I. Eschenbachgasse, *No.* 9, *Wien. Per year* 10 *Fl.*

SWITZERLAND AND BELGIUM.

Allgemeine Schweizerische Militaer-Zeitung. [*A.S.M. Zeitung.*] *Weekly.*
Basel, *Switzerland. Per year*, 8 *Fr.*

La Belgique Militaire. [*Belgique M.*] *Weekly.*
Rue St. Georges 32, *Ixelles*, *Belgium. Per year* 12.50 *Fr.*

Monatschrift fuer Offiziere Aller Waffen. [*Monatschr.*] *Monthly.*
Frauenfeld, *Switzerland. Per year* 5 *Fr.*, *plus postage.*

Revue de l'Armée Belge. [*A. Belge.*] *Bi-monthly.*
22 *Rue des Guillemins*, *Liège*, *Belgium. Per year* 13 *Fr.*

Revue Militaire Suisse. [*R. M. Suisse.*] *Monthly.*
Escalier-du-Marché, *Lausanne*, *Switzerland. Per year* 10 *Fr.*

Schweizerische Zeitschrift fuer Artillerie und Genie. [*S. Zeitschrift.*]
Monthly.
Frauenfeld, Switzerland. Per year 8 *Fr.* 20 *centimes.*

SPAIN, PORTUGAL AND SOUTH AMERICA.

Boletin del Centro Naval. [*Boletin.*] *Monthly.*
438 *Alsina, Buenos Aires, Argentina Republica. Per year* $11.00.

Circulo Naval,—Revista de Marina. [*R. de Marina.*] *Monthly.*
Casilla num. 852, *Valparaiso, Chili.*

Memorial de Artilleria. [*M. de Art.*] *Monthly.*
Farmacia, num. 13, *Madrid, Spain. Per year, U. S.*, $3.40.

El Porvenir Militar. [*Porvenir.*] *Weekly.*
258 *Calle Montevideo, Buenos Aires, Argentina. Per year* 10 $ $\frac{m}{n}$.

La Prensa Militar. [*Prensa.*] *Weekly.*
Reconquista 1034, *Buenos Aires, Argentina.*

Revista Cientifico-Militar. [*Cientifico M.*] *Semi-monthly.*
5 *Calle de Cervantes, Barcelona, Spain. Per year* 32 *Fr.*

Revista da Commissao Technica Militar Consultiva. [*R. da Commissao.*]
Bi-monthly. Praça da Republica N. 32, *Rio de Janeiro, Brazil.*

Revista de Engenheria Militar. [*Engenheria Mil.*] *Monthly.*
27 *Rua Nova do Almada, Lisbon, Portugal. Per year* 1 $ 800 *réis.*

Revista do Exercito e da Armada. [*Exercito.*] *Monthly.*
Largo de S. Domingos No. 11, *Lisbon, Portugal. Per year U. S* $6.00.

Revista General de Marina, [*R. G. de Marina.*] *Monthly.*
56 *Calle de Alcalá, Madrid, Spain. Price U. S.* $4.45.

Revista Maritima Brazileira. [*R.M. Brazil.*] *Bi-monthly.*
Rue do Conseheiro Saraiva n. 12. *Rio de Janeiro, Brazil. Per year* $10.00.

Revista Militar. [*R. Mil. Portugal.*] *Semi-monthly.*
262 *Rua da Princeza, Lisbon, Portugal. Per year,* $2.60.

Revista Militar. [*R. Mil. Chile.*] *Monthly.*
Santiago, Chili.

HOLLAND AND SCANDINAVIA.

Artillerie-Tidskrift. [*Art. Tids.*] *Bi-monthly.*
Stockholm, Sweden. Per year, U. S., $1.75.

De Militaert Gids. [*M. Gids.*] *Bi-monthly.*
De Erven F. Bohn, Haarlem, Holland. Per year, U. S., $2.00.

Militaert Tidsskrift. [*M. Tids.*] *Bi-monthly.*
Copenhagen, Denmark. Per year, U. S., $2.50.

Norsk Militeert Tidsskrift. [*N. M. Tids.*] *Monthly.*
Christiania, Norway. Per year, U. S., $2.50.

RUSSIA.

Artilleriiskii Journal. [*Art. Journal.*] *Monthly.*
Furschtatskaia Ulitza, St. Petersburg, Russia.

Razviedchik. [*Razv.*]
KoloKolwaia Ulitza, No. 14, *St Petersburg, Russia.*

Russkii Invalide. [*Invalide.*]
Wadizdinskia Ulitza, No. 48, *St. Petersburg, Russia.*

ITALY.

Rivista di Artiglieria é Genio. [*R. Artig.*] *Monthly.*
Tipografia Voghera Enrico, Rome. Per year 30 *L.*

Rivista Marittima. [*R. Maritt.*] *Monthly.*
Rome. Per year 25 *L.*

UNITED STATES.

American Engineer and Railroad Journal. [*Eng. and Rail. Jour.*] *Monthly.*
140 *Nassau Street, New York City. Per year* $2.00.

American Journal of Mathematics. [*Jour. Math.*]
John Hopkins University, Baltimore, Md.

American Machinist. [*Amer. Mach.*] *Weekly.*
256 *Broadway, New York City. Per year* $3.00.

American Manufacturer and Iron World. [*Man. and Iron World.*] *Weekly.*
59 *Ninth Street, Pittsburgh, Pa. Per year* $4.00.

Annual of the Office of Naval Intelligence. [*Naval Intelligence.*]
Washington, D. C.

Army and Navy Journal. [*A. and N. J.*] *Weekly.*
New York City. Per year $6.00.

Army and Navy Register. [*A. and N. R.*] *Weekly.*
Washington, D. C. Per year $3.00.

Bulletin of the American Mathematical Society. [*Bulletin Math. Soc.*]
University Heights, New York City.

Cassier's Magazine. [*Cas. Mag.*] *Monthly.*
3, *West* 29*th Street, New York City. Per year* $3.00.

Digest of Physical Tests. [*Digest.*] *Quarterly.*
1424 *N.* 9*th Street, Philadelphia. Per year* $1.00.

Electrical Engineer. [*Elec. Eng.*] *Weekly.*
203 *Broadway, New York City. Per year* $3.00.

Electrical Engineering. [*Elec. Eng'ing.*] *Semi-Monthly.*
443 *The Rookery, Chicago, Ill. Per year* $1.00.

Electrical Review. [*Elec. Rev. N. Y.*] *Weekly.*
41 *Park Row, New York City. Per Year* $3.00.

The Engineer. [*Eng. N. Y.*] *Fortnightly.*
106-108 *Fulton Street, New York City. Per year* $2.50.

Engineering Magazine. [*Eng'ing. Mag.*] *Monthly.*
120-122 *Liberty Street, New York City. Per year* $3.00.

Engineering News and American Railroad Journal.
[*Eng'ing News and R.R. Jour.*] *Weekly.*
220 *Broadway, New York City. Per year* $5.00.

Engineering and Mining Journal. [*Eng. and Min. Jour.*] *Weekly.*
253 *Broadway, New York City. Per year* $5.00.

The Iron Age. [*Iron Age.*] *Weekly.*
96-102 *Reade Street, New York City. Per year* $4.50.

Journal of Electricity. [*Jour. Elec.*] *Monthly.*
421 *Market Street, San Francisco, Cal.*

Journal of the American Chemical Society. [*J. Chem. S.*] *Monthly.*
Easton, Pa. Per year $5.00.

Journal American Society of Naval Engineers. [*A.S.N. Egrs.*] *Quarterly.*
Navy Department, Washington, D. C.

Journal of the Association of Engineering Societies. [*Eng. Soc.*] *Monthly*
257 *South Fourth Street, Philadelphia. Per year* $3.00.

Journal of the Franklin Institute. [*Frank. Inst.*] *Monthly.*
Philadelphia, Pa., Per year $5.00.

Journal of the Military Service Institution. [*Jour. M. S. I,*] *Bi-monthly.*
Governor's Island, New York City. Per year $4.00.

Journal of the U.S. Cavalry Association. [*Jour. U. S. Cavalry*] *Quarterly.*
Fort Leavenworth, Kansas.

Journal of the Western Society of Engineers. [*W. Soc. Eng.*] *Bi-monthly.*
1737 *Monadnock Block, Chicago, Illinois. Per year* $2.00.

Marine Review. [*Mar. Rev.*] *Weekly.*
Cleveland, Ohio. Per year $2.00.

Military Information Division. [*Mil. Information Div.*] *Occasional.*
War Department, Washington, D. C.

Notes on Naval Progress. [*Naval Intelligence.*] *Occasional.*
Navy Department, Washington, D. C.

Pennsylvania Magazine of History and Biography. [*Penn. Mag. of Hist.*] *Quarterly.*
13 *Locust Street, Philadelphia. Per year* $3.00.

The Photographic Times. [*Phot. Times.*] *Weekly.*
60 *and* 62 *E.* 11*th Street, New York City. Per year* $5.00.

Physical Review. [*Phys. Rev.*] *Bi-monthly.*
Cornell University, Ithaca, New York. Per year $3.00.

Popular Science Monthly. [*Pop. Sc. Mo.*] *Monthly.*
72 *Fifth Avenue, New York City. Per year* $5.00.

Proceedings of the American Philosophical Society.
[*Proceedings of A. Phil. Soc.*]
104 *South Fifth Street, Philadelphia, Pa.*

Proceedings of the U. S. Naval Institute. [*Naval Inst.*] *Quarterly.*
Annapolis, Md. Per year $3.50.

Public Opinion. [*Pub. Opin.*] *Weekly.*
New York City. Per year $2.50.

Review of Reviews. *Monthly.*
13 *Astor Place, New York City. Per year* $2.50.

The Scientific American. [*Scien. Amer.*] *Weekly.*
361 *Broadway, New York City. Per year* $3.00.

Shooting and Fishing. *Weekly.*
293 *Broadway, New York City. Per year* $3.50.

Technology Quarterly. [*Tech. Quart.*] *Quarterly.*
Mass. Inst. of Tech., Boston, Mass. Per year, $3.00.

Transactions American Institute of Electrical Engineers.
[*Inst. Elec. Eng'rs.*] *Monthly.*
26 *Cortlandt Street, New York City. Per year* $5.00.

Transactions American Institute of Mining Engineers.
[*Trans. Inst. Min. Eng'rs.*]
P. O. Box 225, *New York City.*

Transactions of the American Society of Civil Engineers.
[*Trans. A. S. Civil Eng'rs*]
220 *West* 57*th Street, New York City.*

Transactions of the American Society of Mechanical Engineers.
[*Trans. A. S. Mech. Eng'rs.*]
12 *West* 31*st Street, New York City.*

Transactions of the Society of Naval Architects and Marine Engineers.
[*Naval Architects and Marine Eng'rs.*]
12 *West* 31*st Street, New York City.*

Western Electrician. [*West. Elec.*] *Weekly.*
510 *Marquette Building, Chicago, Illinois. Per year* $3.00.

Wilson's Photographic Magazine. [*Phot. Mag.*] *Monthly.*
853 *Broadway, New York City. Per year* $3.00.

ORGANIZATION AND ADMINISTRATION.

Our state of defense, U. S.—**Pub. Opin., March 3.**

The American naval officer of the future (fighting engineers).—**Cas. Mag.,** March.

The strength of the English army.—**Wochenblatt, March 16.**

The English army and navy.—**R. Maritt., March; Int. Revue, February.**

The Federal defense of Australia.—**Jour. R. U. S. I., February.**

Army reorganization: with especial reference to the infantry of the line and militia.—**Jour. R. U. S. I., March.**

The fortification of our dockyards.—**Jour. R. U. S. I., February.**

The French army (practice camps, the 4th battalions, increase of the army of the I. line, etc.).—**A. S. M. Zeit., February 26.**

The defense of our coasts, France.—**Yacht, March 5.**

The defense of coasts and the food supply of the intrenched camp at Paris. —Marine F., February 15.

The German army in 1897.—**A. S. M. Zeit., March 12.**

Saxon army list for 1898.—**Wochenblatt, February 12.**

The naval question in Germany.—**Jahrbuecher, February.**

Budget of the German navy for 1898.—**Seewesens, March.**

The Austro-Hungarian army and its last year's maneuvers at Totis.—**Monatschr,** February.

Italian army matters.—**A. S M. Zeit., February 26.**

Italian army organization. —**Wochenblatt, February 12.**

The reorganization of the Italian army.—**Etranger, December.**

History of army reorganization in Italy, 1896-97.—**Int. Revue, March.**

The defensive strength of Russia.—**Jour. R. U. S. I., March.**

The recently made changes in the Russian army.—**Int. Revue, March.**

The present organization of the Cossacks.—**Etranger**, February.

The regulation of the Engineer Corps in the Russian army.—**R. Artig.**, January.

The military system of Russia, what it is and what it ought to be.—**Heeres-Zeit.**, February 9, 12, 23; **A. M. Zeit.**, February 17, 21.

Russian sea strength, 1898.—**Int. Revue**, March.

The armed strength of the Balkan states.—**Heeres-Zeit.**, March 9.

The Chinese navy.—**Marine F.**, April 15.

The organization of the Brazilian navy.—**R. M. Brazil, October, December.**

Naval forces in 1897.—**R. G. de Marina**, March.

Naval recruiting.—**R. Maritt.**, February.

The recruitment and promotion of officers of the principal European armies.—**Exercito**, February.

Field clothing and subsistence of the foot soldier in active service.—**R. Infanterie**, March.

The organization and training of scouts.—**Jour. U. S. I., India, January.**

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Infantry tactics.—**R. Infanterie, February.**

The question of infantry attack.—**Jahrbuecher, February, March; Int. Revue**, March.

The combat.—**Cercle**, February 26, March 5.

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STRATEGY.

Lines of Concentration of the German armies towards the French frontier.—**Jour. R. U. S. I.**, February.

The battle of Bautzen from a commander's point of view.—**Jahrbuecher**, February.

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The great siege of Malta, 1865.—**Jour. R. U. S. I.**, February.

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Progress in the Soudan.—**Int. Revue**, March.

History of the infantry in France.—**R. Infanterie**, February, March.

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England and Germany from a maritime point of view.—**Int. Revue**, February.

General Kuropàtkin, the new Russian war minister.—**A. M. Zeit.**, February 3.

Mahan and Callwell.—**R. Maritt.**, February, March.

The national study of military history.—**Jour. R. U. S. I.**, May.

DRILL REGULATIONS AND MANEUVERS.

Infantry drill regulations, 1896, Dutch army.—**M. Gids.**, 2, 1898.

The drills of the English volunteers at Aldershot.—**Wochenblatt**, February 23.

Drill regulations of the German cavalry, September, 1895.—**Monatschr**, January.

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The new regulations for the German field artillery.—**Jahrbuecher**, February.

Practice march for testing the 7.5 cm. rapid-fire mountain material.—**Cientifico M.**, February 1, 15.

Distance ride of the riding school for instruction of infantry officers, Switzerland.—**Monatschr**, February.

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The marching of infantry.—**U. S. Gaz.**, March 19.

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Means of improving the fire of infantry.—**Int. Revue**, March.

The development of musketry in the German infantry, 1884-1897.—**Int. Revue**, February.

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Camps of instruction in foreign armies.—**Etranger**, December.

Instruction and training of officers.—**S. Zeitschrift**, January.

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ARTILLERY MATERIAL.

Krupp's 7.5 cm. rapid-fire mountain gun in the campaign of Cuba.—**M. de Art.**, December.

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The Maxim gun.—**Eng'ing.**, March 18.

The 75 mm. rapid-fire field material, Maxim-Nordenfelt system.—**R. Artillerie**, February.

The rapid-fire field gun of the German artillery, (from official sources).—**R. M. Suisse**, March.

Schneider, Thronsen and Nordenfelt rapid-fire campaigning material.—**R. Artig.**, January.

Schneider-Canet quick-firing breech mechanism.—**Eng.**, February 11.

The new single-forged cannon.—**Scien. Amer.**, March 19.

Humbert's noiseless gun.—**Scien. Amer.**, March 19

The construction of modern wire-wound ordnance.—**Eng.**, February 18, March 18.

Study on the methods of harnessing and draught in field artillery carriages of the principal European armies.—**R. Artillerie**, February.

Conditions that field artillery material should fulfil and efforts now to be observed abroad in improving that of the present.—**M. de Art.**, January.

A new armor plate alloy.—**Eng. and Min. Jour.**, March 19.

Armor and the navy, England. **Eng.**, March 18.

Messrs. Schneider and Co's. works at Creusôt. **Eng'ing.**, March 4, 11, 18; February 11, 18, 25.

Herr Krupp's works, Essen. **Eng.**, February 18.

Schneider-Canet quick-firing ammunition. **Eng.**, February 18.

A new powder.—**Umschau**, March 12.

Plastomenite.—**Heeres-Zeit.**, March 5; **Belgique M.**, March 13; **S. Zeitschrift**, February.

Förster's cubical smokeless powder. **S. Zeitschrift**, January.

The storage of explosives.—**Eng. and Min. Jour.**, March 12.

Cavalry pioneer tools and high explosives as used in the armies of Europe. **Mil. Information Div.**, XVI, part 2.

Conclusion of the vocabulary of powders and explosives.—**R. G. de Marina**, February, March.

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Progress in naval war material in 1897, England.—**R. G. de Marina**, February.

BALLISTICS, RANGE FINDING AND POINTING.

Calculations of ballistic co-efficients in high angle flight.—**Mitth. Art. u. G.**, No. 2, 1898.

Complementary parameters in rational ballistics.—**R. Artig., January.**

A method of obviating some imperfections in coast defense fire.—**R. Artig.**, January.

An essay on a practical course of fire.—**R. Infanterie, February, March.**

METALLURGY.

Proofs of metals for tensile strength and expansion.—**Mar. Rundschau**, March.

The blast furnaces at the Creusôt works, France.—**Eng. and Min. Jour.**, March 5.

The bases of expert knowledge of steel and iron for military purposes.—**Heeres-Zeit.**, February 23, 26.

ELECTRICITY AND HYDRAULICS.

Note on the electric light installation at Verdun.—**Génie M., February.**

Electrical equipment of the *Maine*.—**Elec. Eng., March 10.**

Electrical communication with coast defenses.—**Western Elec., March 19.**

Electrical engineering at Columbia University.—**Elec. Eng., March 17**; **Western Elec.**, March 12.

Electrical steering apparatus.—**Mar. Rundschau**, March.

Electric generators.—**Eng'ing.**, March 18.

Sparking, its causes and effects.—**Inst. Elec. Eng'rs.**, January.

Powerful electric discharges.—**Elec. Rev.**, March 9.

Tests of the synchronograph on the telegraph lines of the British Government.—**Frank. Inst.**, March.

Wireless telegraphy.—**Inst. Elec. Eng'rs.**, January.

Note on telegraphy without wires.—**R. Artillerie**, February.

Magnet winding curves.—**Elec. Eng.**, March 24.

Aluminum as a rival of copper and brass for electrical conductors.—**Elec. Rev.**, March 2.

The electrical development of hydraulic power.—**Eng'ing. Mag.**, March.

Hydraulic rams.—**Iron Age**, March 10.

FORTIFICATIONS.

Fortified places and coast defenses of the United States.—**Heeres-Zeit.**, March 16.

Hasty intrenchments in the War of Secession.—**Jour. M. S. I.**, March.

Recent strengthening of Hong-Kong.—**Eng.**, February 18.

BICYCLES, AEROSTATION AND PHOTOGRAPHY.

The military bicycle in Belgium.—**Cercle**, February 12.

Horse and cycle.—**Heeres-Zeit.**, February 9.

The future of military cycles.—**A. M. Zeit.**, February 3.

Automatic carriages as aids in warfare.—**Wochenblatt, January 5.**

The latest developments in the military applications of the bicycle and balloons.—**Umschau,** February 12.

The importance of ballooning in wars of the future.—**Heeres-Zeit.,** February 26, March 2.

On color photography.—**Photo. Times,** March.

Color processes.—**Photo. Jour.,** February.

A new system of flash-light photography.—**Photo. Times,** March.

SMALL ARMS AND EQUIPMENTS.

The Mauser repeating pistol.—**Arms and Expl.,** March.

The new carbine and new target practice, U. S.—**Jour. M. S. I.,** March.

The new Lee straight pull rifle.—**Arms and Expl.,** March.

Modern fire-arms and musketry.—**Heeres-Zeit.,** February 9.

The Kynoch cartridge factory.—**Arms and Expl.,** March; **Eng'ing.,** March 4.

The employment of aluminum in the French army.—**Wochenblatt,** January 5.

MILITARY GEOGRAPHY.

The eastern frontier of France.—**Int. Revue,** February.

French colonial possessions in Africa.—**Int. Revue,** February.

Obok and the country bordering on the Gulf of Tajura.—**Jour. R. U. S. I.,** May.

The extreme East.—**R. G. de Marina,** February.

Kiao-Chan.—**Mar. Rundschau,** March; **A. M. Zeit.,** February 3, 7.

Military study of Menorca.—**M. de Art.,** December, January.

Strong lights on the Mediterranean.—**Mar. Rundschau,** March.

The extension of the port of Antwerp.—**Eng.,** March 18.

General ideas on Mexico.—**R. G. de Marina,** March.

Proposed canal from the American Lakes to the Atlantic.—**Eng'ing.,** March 11.

MILITARY SCHOOLS.

The Royal Military Academy and Royal Military College reports.—**U. S. Gaz.,** March 19.

The entrance and military instruction of aspirants for the Marine Guards and Cadets.—**R. G. de Marina,** February, March.

Admission examinations at the High War College, 1898, France (tactics).—**Cercle,** March 12.

The cavalry school at Pignerol, Italy.—**A. M. Zeit.,** February 3.

The Spanish High War College.—**Cercle,** March 12.

Service school for heavy artillery, U. S.—**Jour. M. S. I.,** March.

MILITARY ENGINEERING.

A new method for foundations in bad ground by mechanical compression of the soil.—**Génie M.,** February.

Steel concrete construction.—**Proceedings A. S. Civil Eng'rs.,** March.

War observatories constructed of bridge materials.—**R. Artig.,** January.

Rapid bridge construction in America.—**R. Artig.,** January.

Wooden or iron pontoons.—**S. Zeitschrift,** February.

WARSHIPS AND TORPEDO BOATS.

The new U. S. battleships.—**Seewesens,** March; **Mar. Rev.,** March 17.

Our recently purchased warships, U. S.—**Scien. Amer.,** March 26.

Spain against the United States (comparison of their navies).—**Iron Age**, March 17.

Vessels of the United States and Spain, (illustrated).—**A. and N. Jour.**, March 26.

Spanish destroyers and torpedo boats destined for Cuba.—**Scien. Amer.**, March 19.

The Spanish cruiser *Cristobal Colon.*—**Eng'ing.**, February 18.

The U. S. battleship *Maine.*—**Eng'ing.**, February 18; **Eng.**, March 18; **Mar. Rev.**, March 3.

The catastrophy of the *Maine.*—**R. G. de Marina**, March; **Pub. Opin.**, March 3; **Scien. Amer.**, March 12.

The *Katahdin.*—**R. G. de Marina**, March.

The conning tower of the gunboat *Helena.*—**Scien. Amer.**, March 26.

British and foreign types of battleships.—**Eng.**, March 18.

Gun and steam trials of H. M. S. *Illustrious.*—**Eng'ing.**, March 18.

Trials of the *Diadem.*—**Eng'ing.**, February 18.

Ship building and marine engineering on the Thames in the Victorian era. —**Eng.**, February 11, March 18.

Ship building in 1897.—**Eng.**, February 18, March 18.

The French warship building program.—**Seewesens**, March.

The new first-class battleship *Charles Martel.*—**Jour. R. U. S. I.**, January.

The French marine.—**Eng.**, February 11.

The Japanese first-class battleship *Yashima.*—**Jour. R. U. S. I.**, February.

Large shells and the armor of cruisers.—**Yacht**, March 5.

The automatic closing of holes made by projectiles.—**Yacht**, March 12.

Ironclads in action.—**Jour. R. U. S. I., India**, January.

Broadside submerged torpedo tubes.—**Jour. R. U. S. I.**, February.

Above water and submerged torpedo tubes.—**R. Maritime**, March.

The building of a ship.—**Cas. Mag.**, March.

A new Norwegian warship.—**Eng.**, February 18.

Employment of torpedo boats. **R. Maritime**, January.

The construction of the Lorain dry dock and shipyard of the Cleveland Shipbuilding Co.—**Proceedings A. S. Civil Eng'rs.**, March.

MISCELLANEOUS.

The manufacture of paper.—**Scien. Amer.**, March 19.

The Severy impression process.—**Frank. Inst.**, March.

The Diesel motor.—**Eng. News and R. R. Jour.**, March 17; **Scien. Amer.**, March 12; **A. S. N. Eng'rs.**, February.

Discovery of new chemical elements.—**Pop. Sc. Monthly**, April.

The interpretation of sanitary water analyses.—**Eng'ing. Mag.**, April.

Effects of the penetration of small caliber bullets.—**Cientifico M.**, February 1.

The construction of slow-burning buildings.—**Eng'ing. Mag.**, March.

On calculating machines.—**Mitth. Art. u. G.**, No. 2, 1898.

The study of Oriental languages in the Russian army.—**Int. Revue**, February.

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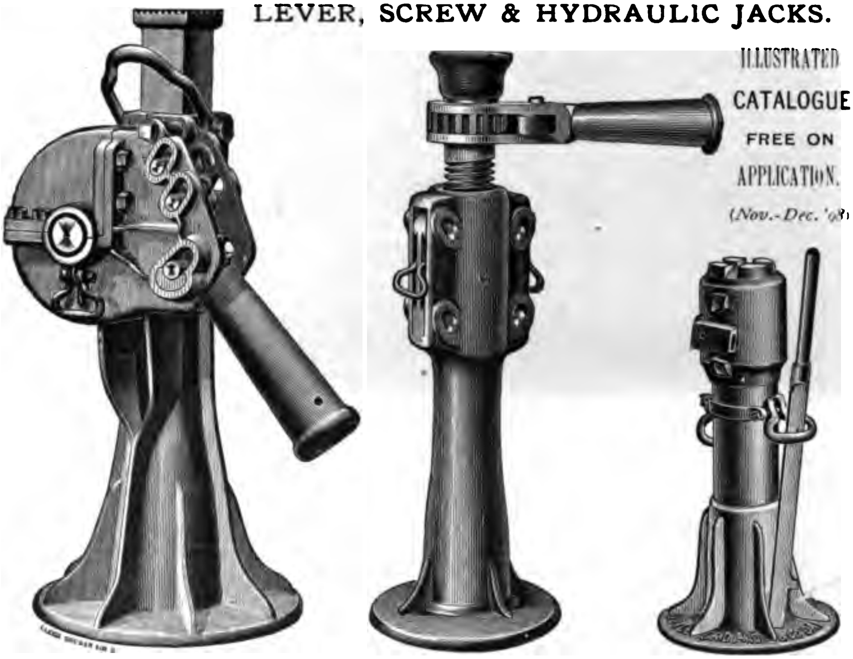

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